Document No. Y/EXT-00153/DEL REV | Author's Telephone No. 6-0263 | Acct. No 2366000 $ | Date of Request 5/15/96

Unclassified Title: HISTORICAL REVIEW OF ACCOUNTABLE NUCLEAR MATERIALS AT THE Y-12 PLANT

Author(s) Requestor: Steve Wiley

TYPE: ☐ Formal Report ☐ Informal Report ☐ Progress/Status Report ☐ Co-Op Report ☐ Thesis/Term Paper

☐ Oral Presentation (identify meeting, sponsor, location, date):

☐ Journal Article (Identify Journal):

☒ Other (Specify): To Be Released to ChemRisk, Phase II

Document will be published in proceedings ☑ No ☐ Yes

Document will be distributed at meeting ☑ No ☐ Yes

Document has patent or invention significance ☑ No ☐ Yes (Identify)

Document has been previously released ☑ No ☐ Yes (Reference)

DIVISION REVIEW AND APPROVAL (Completed By Requesting Division)

TECHNICAL CLASSIFICATION REVIEW (Divisional Classification Representative)

Title(s): U Abstract: U

DOCUMENT: Level Secret* Category RD

[signature] 5-28-96
Signature Date

(*classified information bracketed)

DOCUMENT REQUEST APPROVED (Division or Department)

[signature] 5/16/96
Signature Date

Signature Date

THE REMAINDER OF THIS FORM TO BE COMPLETED BY THE TECHNICAL INFORMATION OFFICE

DISTRIBUTION

☐ Internal Distribution
☐ External Distribution
TID-4500 Category ______ or ______ Copies to OSTI
ANNOUNCED IN ERA Atomindex (Available from NTIS)
M-3679 Category
ANNOUNCE IN: ☐ AWDR (Available from OSTI) ☐ ANCR

Distribution: UCN-7721B DOE F-1332.15 Documer
Y-12 Central Files Y-12 RC Y-12 RC Y-12 RC
TIO File L.L. McCauley
S.W. Wiley
R.M. Keyser

Distribution Remarks: Unlimited (ChemRisk)

APPROVAL AND RELEASE

Date Received | Date Initiated 5/15/96

☒ CLASSIFICATIONS.

Title(s): U Abstract —

DOCUMENT:

Level U (w/DELETIONS) Category —

Weapons Data — Sigma —

[signature] 5/29/96
Y-12 Classification Office Date

☐ Editor Date

☒ waived P. McKenney
Patent Office Date

☐ Date

☐ Date

APPROVED FOR: ☐ Declassification ☐ Release subject to use of the following admonitory markings and conditions:

☐ Disclaimer ☐ Copyright ☐ Patent Caution ☐ Other

P.L. McKenney 6/3/96
Technical Information Office Date

Conditions/Remarks.

(

Y/EXT-00153/DEL REV

Extracted pages
Historical Review of Accountable Nuclear Materials at the Y-12 Plant

Authorized Derivative Classifier
M.D. Trundle 5-28-96
Authorized Signature Date

Authorized Derivative Declassifier
R Baylor Jr 5/29/96
Authorized Signature Date

This material has been reviewed by the Y-12 Classification office and has been determined to be UNCLASSIFIED.

APPROVED FOR PUBLIC RELEASE
P. L. McKinney 6/3/96
Technical Information Office Date

THIS PAGE MUST NOT BE SEPARATED FROM THE ATTACHED DOCUMENT

Enclosure
Letter, Butz to Spence
Dated:

~~Y/DG-25649~~
~~Revision 2~~
Y/EXT-00153/DEL REV

Historical Review of Accountable Nuclear Materials at the Y-12 Plant

Compiled by: Edward Owings

July 28, 1995

Distribution:
R. M. Keyser/W. H. Hopwood, Jr. - RC
W. L. Clements/R. R. Abbott
M. K. Morrow/R. K. Roosa
G. R. Proco, DOE-ORO
R. J. Spence, DOE-ORO

RESTRICTED DATA
~~This document contains Restricted Data as defined in the Atomic Energy Act of 1954. Unauthorized disclosure subject to~~ Administrative and Criminal Sanctions.

~~Derivative Classifier~~ E. A. Fyk 9/25/95
~~Date~~

Acknowledgements

This report would not have been possible without the help of Mr. W. H. Hopwood, Jr., and Mr. W. B. Kenna of the Nuclear Materials Control and Accountability (NMC&A) Department, and Mr. Robert A. Harris, Department of Energy, Oak Ridge Operations (DOE-ORO), retired. Mr. Hopwood's knowledge of the accountability system and assistance as consultant was very helpful. Mr. Kenna supplied much information for this document especially about deuterium and lithium. Mr. Harris was generous by giving permission to use any and/or all of the document he authored, "Control of Nuclear Materials at the Y-12 Plant," dated September 21, 1983. Much of his document describing the system for control and accountability of enriched uranium above 20 percent ^{235}U is included in this report. Other important contributors to this document include, Mr. L. D. Lambert of Y-12 Protective Services, Mr. D. L. McMurray and Mrs. K. C. Jeffers of NMC&A, and two former employees, Mrs. M. S. Franklin and Mr. P. E. Wilkinson.

~~RESTRICTED DATA~~
~~This document contains Restricted Data~~ ~~as defined in the Atomic Energy Act of~~ 1954. Unauthorized disclosure subject to Administrative and Criminal Sanctions.

Historical Review of Accountable Nuclear Materials at the Y-12 Plant

Historical Review of Accountable Nuclear Materials at the Y-12 Plant (U)

1.0 Abstract

Since 1947, control and accountability of various materials have been maintained through rigid systems of operational and administrative controls; and these systems have been continually monitored and upgraded to meet the requirements imposed by the United States Atomic Energy Commission (USAEC), Energy Research and Development Administration (ERDA), and the Department of Energy (DOE). A primary indicator of the effectiveness of the control system has been the monthly comparison of book versus physical inventory, a value currently termed inventory difference or "ID." The major contributors to the cumulative IDs resulted from assumptions and estimates used where measurement methods were not available. Subsequent adjustments to the cumulative IDs were not made. Given the overall controls and related studies there is no evidence of significant safeguards or safety vulnerabilities. Much has been done over the years to upgrade the overall materials control and accountability (MC&A) system and is currently being done from both an administrative and operational standpoint.

2.0 Introduction

2.1 Purpose

This document is intended to satisfy the request of Mr. Garland Proco as described in a memo from Mr. Robert J. Spence to Mr. D. J. Bostock, dated April 27, 1993, "Analysis of Historical Nuclear Material Inventory Difference and Other Book Adjustments." As stated in the memo, nuclear facilities in DOE are consolidating materials and proceeding with closure of operating areas. This change in the character of the facilities will inevitably lead to questions about the accountability of materials that have been on inventory. In anticipation of such questions, the DOE-Oak Ridge Operations (ORO) manager's office has decided that we should have a historical analysis conducted at each of the ORO nuclear facilities. The analysis should contain details at the material balance area (MBA) level for each type of material that has been processed or stored there. The analysis should include annual and summary data on throughput, IDs, normal operating losses, and adjustments to the books for other reasons.

2.2 Scope

Detailed data are not available for nuclear material transfers and flows at the Y-12 Plant prior to 1947. However, summaries were found of operations (Alpha and Beta) for the Electromagnetic Process and have included these as items 3.1.1 and 3.1.2 in this document. The data from the Electromagnetic Operation (1944 - 1946) has not been integrated with Y-12 Plant Operations (1947 to present), because it is not believed the traditional accounting rigor was employeed nor complete records kept. Both sets of data are "stand alone." With the exception of section 3.1, this document will address the time period calendar year (CY) 1947 through fiscal year (FY) 1994. Also, there is a very wide variety of special nuclear, source, and other nuclear materials accounted for at the Y-12 Plant. The various materials in this report include enriched uranium above 20 percent ^{235}U, enriched uranium below 20 percent ^{235}U, depleted uranium, normal uranium, thorium, enriched lithium (40 percent, 60 percent, and 95 percent ^{6}Li), deuterium, plutonium, ^{233}U, While the Y-12 Plant has many interfaces with operations throughout the nuclear industry, the control of the various materials described above begins and ends with the receipt at the Nuclear Materials Safeguarded Shipping and Storage (NMSSS) Warehouse and shipment from the plant.

2.3 Definitions as set forth in DOE guidance and the MC&A Plan, Y/DG-19839.

Accidental Loss. An uncontrolled or unplanned release of quantities of nuclear material as a result of an operation accident. The quantity of material involved may be derived through either measurement or a defensible estimate.

Accountable Material. A term that includes all nuclear materials which must be controlled and accounted for by the plant.

Accountability Measurement. The quantitative determination of bulk or nuclear materials accounting.

Accuracy. A measure of the agreement between the true value and the measured value.

Actual ID. The portion of the ID that is not explained inventory difference (EID), expressed mathematically as ID minus EID equals actual inventory difference (AID).

Adjustment. An entry into the nuclear material accounting records to reflect an approved, justified, and documented change.

Administrative Check. A review to determine that no irregularities appear to exist and no items are obviously missing.

Alarm Limits. Established values for IDs of nuclear materials which, when exceeded, require immediate action and reporting in accordance with DOE Order 5000.3B. Note: For processing, production, and fabrication operations, alarm limits will be established with a 99 percent confidence level.

Alloyed Material. The term used to describe a substance formed by the combination of two different materials. Both materials may be accountable i.e., [redacted] or only one may be accountable (i.e., [redacted]. The material may also be referred to as traced.

Alternate MBA Custodian. An individual assigned to assume the responsibility for the control and accountability of accountable materials within an MBA in the absence of the MBA custodian.

Apparent Loss. The inability to physically locate or to otherwise account for any of the following:

a. Any identifiable or discrete item (e.g., batch, lot, or piece) containing nuclear materials;
b. A nuclear material ID in which the book inventory is larger than the physical inventory by an amount in excess of the established alarm limit;
c. A shipper/receiver (S/R) difference involving a discrepancy in which fewer items were received than were shipped; or
d. A S/R difference whose magnitude exceeds the combined limit of error for the shipment and for which the receiver measures less material than the shipper.

Approved Write-off. The disposal of measured values of nuclear material by special request which occurs when discards are unusually large (above approved allotments). This term also includes known quantities of "good" material which, with prior approval by the cognizant field office, have been removed from inventory records. Approved write-offs are usually restricted to "good" material which has been used in such a manner as to lose its identity and for which accountability is no longer deemed necessary.

Area Breach Report. A report which is signed by various members of plant management after an evacuation or nonroutine exit from a controlled special nuclear material (SNM) area. The SNM emergency inventory director signs this document to certify the results of an SNM emergency inventory.

Batch. A discrete item to which a unique identification number can be used. The identification number on nuclear material items must agree with Dynamic Special Nuclear Material Control and Accountability System (DYMCAS).

Batch Card. A multi-ply form used to record data on the transfers of nuclear material between MBAs or transactions within MBAs.

Beginning Inventory (BI). The quantity of nuclear materials on hand at the beginning of an accounting period.

Bias. The deviation of the expected value of a random variable from the corresponding true or assigned value.

Book Inventory. The quantity of nuclear material present at a given time as reflected by accounting records.

Category. A designation (Category I, II, III, or IV) of a quantity of SNM or of an SNM location based on the attractiveness le[illegible] of the material and the amount of material present. Precise directions for t[illegible]etermination of nuclear material categories are given in Chapter I, paragraph [illegible].

Certified Reference Material. A reference material, one or more of whose property values is certified by a technically valid procedure, accompanied by or traceable to a certificate of other documentation which is issued by a certifying body.

Confirmation Measurement. A measurement made to test whether some attribute or characteristic of nuclear material is consistent with the expected attribute or characteristic for that material.

Control Limits. The established values beyond which any variation, in this case ID, is considered to indicate the possibility of an assignable cause. Control limits established at the 95 percent confidence level are called warning limits. Those established at the 99 percent confidence level are called alarm limits.

Diversion. The unauthorized removal of nuclear materials from its approved use or authorized location. Note: The definition of "authorized locations" in the context of diversion of nuclear materials is the responsibility of the cognizant DOE Operations Office.

Discards or Normal Operating Loss (NOL). Known quantities of material determined by measurement or by estimate on the basis of measurement which have been intentionally removed from inventory and disposed of by approved methods. The NOLs result when known quantities of nuclear materials are separated from a process or operation as waste during processing and are determined to be uneconomical to recover. The NOLs at Y-12 are disposed to the oxide vault/storage (MBA 93), waste treatment facilities (MBA 94), sewer (MBA 96), burial ground (MBA 98), or the stacks (MBA 99).

DOE-NRC Nuclear Material Transaction Report Form 741 (Form 741). A report form which documents all interplant transfers of nuclear material. It must be distributed in a timely manner to DOE and all participants in the transfer.

DYMCAS. The near real-time computer system used by Y-12 for control and accountability of nuclear materials.

Ending Inventory (EI). The quantity of nuclear materials on hand at the end of an accounting period.

Enrichment Meter. A portable multichannel stabilized assay meter to determine the ^{235}U enrichment of uranium which is calibrated with certified standards to display the enrichment in percent.

Estimate. A technically defensible approximation of the quantity of SNM based on process parameters and/or material attributes. An estimate is used when a direct measurement of nuclear material amount is not possible.

Explained ID. The portion of the ID accounted for and reported to Nuclear Materials Management and Safeguards System (NMMSS) in one of the following categories: redetermination of discrete items on inventory, redetermination of material in process, process holdup differences, equipment holdup differences, measurement adjustments, rounding, recording and reporting errors, S/R adjustments, and identifiable item adjustments.

External Transfer. A transfer of nuclear material from one reporting identification symbol to another.

Graded Safeguards. A system designed to provide varying degrees of physical protection, accountability, and material control to different types, quantities, chemical composition, physical form, and isotopic composition of SNM consistent with varying levels of attractiveness to possible adversaries.

Holdup. Amount of nuclear material remaining in process equipment and facilities after the in-process material, stored materials, and product have been removed. Estimates or measured values of materials in holdup may be reflected in the facility's inventory record.

In-Process Inventory. The quantity of material in a physical or chemical process area at any specified time.

Internal Control System. A system of administrative and accounting policies and procedures implemented by a facility to ensure proper functioning of the MC&A system. Note: The system includes checks and balances in the division of duties designed so that the work of one will serve to verify the work of another.

Internal Transfer. A transfer of nuclear materials within the same reporting identification symbol (RIS).

Inventory Cutoff. The time at which transfers of materials between MBAs temporarily stops and the physical inventory begins.

Inventory Difference (ID). The algebraic difference between the nuclear material book inventory and the corresponding physical inventory, expressed mathematically as book inventory minus physical inventory equals inventory difference. Note: The term "Total Inventory Difference" is sometimes used instead of inventory difference.

Inventory Observation. An assessment to determine if proper inventory procedures are being followed and to verify that the inventory presented correctly reflects material on hand during inventory.

Inventory Verification. An assessment to determine the accuracy of an MBAs inventory. The activity utilizes a sampling plan to check an MBA inventory to verify physical location, weight, and enrichment of randomly selected batches from a current book inventory.

Item. A single piece or container of nuclear material which has a unique identification, a known nuclear material mass, and whose presence can be visually verified.

Limit of Error. The boundaries within wh- the value of the attribute being determined lies with a specified probability

Material Access Area (MAA). A type of security area authorized to contain a Category I quantity of nuclear material with specifically defined physical barriers located with a protected area and subject to specific access.

Material Accountability Alarm. Alarm resulting from material control indicators (e.g., S/R difference, ID, etc.) exceeding established control limits.

Material Balance Area (MBA). An area that is both the subsidiary account of the facility and a geographical area with defined boundaries, used to identify the location and quantity of nuclear materials in the facility.

MBA Custodian. The individual assigned the responsibility for control and accountability of accountable materials within an MBA.

MBA Operating Departments. Includes all departments which have material control and accountability responsibilities in an MBA.

Material Control Alarm. Alarm from a loss detection element (e.g., SNM monitors, material surveillance) which may indicate abnormal situations and/or unauthorized use/removal of nuclear material.

Material Control and Accountability Plan (MC&A). A documented description of a site or facility's MC&A program. Note: The MC&A Plan may be presented as a separate document or incorporated as part of another document.

Materials Control and Accountability (MC&A) System. See DYMCAS.

Material Surveillance. The collection of information through devices and/or personnel observation to detect unauthorized movements of nuclear material, tampering with containment, falsification of information related to location and quantities of nuclear material, and tampering with safeguards devices.

Material Type Code. A four-digit code which indicates the Y-12 cycle and the physical form of the material.

Material Unaccounted-For (MUF). MUF and ID are synonymous. The term MUF was changed to ID by DOE in approximately 1976.

Measured Value. A quantitative characteristic and its associated uncertainty that has been determined for nuclear materials by measurement of those materials.

Measurement Control. The procedures and activities used to ensure that a measurement process generates measurements of sufficient quality for their intended uses.

Missing Item. An unaccounted-for item which has been appropriately reported and investigated. An item will not be declared missing and reportable to DOE until after it has been investigated by the Protective Services Organization and the NMC&A Department.

Normal Operating Loss (NOL). See Discards.

Nuclear Materials (NM). This term is used to describe source materials, special materials, and other materials, which because of their strategic importance or unique characteristic, must be controlled and accounted for.

NMC&A Auditor. An individual designated by NMC&A management to assess programmatic activities. Responsibilities include scheduling, performing, recommending, and reporting to the related parties.

Nuclear Materials Accounting. The principles and/or practices of systematically recording, reporting, and interpreting nuclear material transaction and physical inventory data.

Nuclear Materials Category. See Category.

Nuclear Materials Control and Accountability (NMC&A) Department. The organization assigned responsibility for interpreting DOE requirements, maintaining records, and developing and implementing procedures for control and accountability of NMs.

Nuclear Materials Custodian. An individual assigned responsibility for the control of nuclear material in a localized area of a facility. Note: The localized area should be limited, where practical, to a single MBA.

Nuclear Materials Management and Safeguards System (NMMSS). The national data base and information support system on NMs controlled by the U.S. Government. All transfers (intraplant and interplant) and inventories of nuclear materials connected with Y-12 must be input to this system.

Nuclear Materials Representative. The person responsible for nuclear materials reporting and data submission to the NMMSS.

Nuclear Materials Safeguarded Shipping and Storage Department. The warehouse area for shipping, receiving, and storing NM. It includes MBAs 83, 85, 86, 87, 88, 90, 91, and 92.

Physical Inventory.

a. The quantity of nuclear material which is determined to be on hand by physically ascertaining its presence using techniques such as sampling, weighing, and analysis.

b. The act of quantifying nuclear material that is on hand by physically ascertaining its presence using techniques such as sampling, weighing, and analysis.

Protracted Theft or Diversion. Theft or diversion resulting from repeated occurrences over an extended period of time.

Precision. A quantitative measure of the variability of a set of repeated measurements.

Reportable Occurrence. Events or conditions to be reported in accordance with the criteria defined in DOE Order 5000.3B. Note: Events or conditions included are emergencies, unusual occurrences, and off-normal occurrences.

Reporting Identification Symbol (RIS). A unique combination of three or four letters that are assigned to each reporting organization by the DOE or the Nuclear Regulatory Commission (NRC) for purposes of identification in the nuclear materials management data base. Note: The term is also used to refer to the reporting organization to which the RIS is assigned.

Sealed Source. Nuclear material generally for use in test and calibration that has been packaged to be environmentally and critically safe.

Shipper/Receiver (S/R) Difference. The difference between the measured quantity of nuclear material stated by the shipper as having been shipped and the measured quantity stated by the receiver as having been received.

Source Material. Depleted uranium, normal uranium, thorium, or any other material determined, pursuant to the provisions of Section 51 of the Atomic Energy Act of 1954, as amended, to be source material or ores containing one or more of the foregoing materials in such concentration as may be determined by regulation.

Special Nuclear Material (SNM). Plutonium, uranium-233, uranium enriched in the isotope 235, and any other material which pursuant to the provisions of Section 51 of the Atomic Energy Act of 1954, as amended, has been determined to be special nuclear material but does not include source material; it also includes any material artificially enriched by any of the foregoing not including source material.

Standard Reference Material. A reference material, one or more of whose property values has been certified by the National Institute of Standards and Technology (formerly the National Bureau of Standards).

Strategic Value. The usefulness of a nuclear material to a potential diverter in constructing a weapon.

Tamper-Indicating. An item containing SNM that is either protected by a tamper-indicating device (TID) or constructed such that removal of SNM cannot be accomplished without permanently altering the item in a manner that would be obvious during visual inspection.

Tamper-Safing. The act of applying a TID.

Throughput. Sum of beginning inventory plus receipts (BI + Receipts) for an accounting period.

Transaction. Any recorded change affecting an inventory data base.

Transfer Check. The act of verifying the shipping container or item count, verifying the TID's integrity including the identification number, and comparing this information with appropriate documentation following the transfer of nuclear material.

Unaccounted-for Item. Any identifiable or discrete item, batch, lot, or piece which cannot be physically located or otherwise accounted for under normal operating procedures. This applies regardless of size, dimensions, or weight of the material.

Variance Propagation. The determination of the value to be assigned as the uncertainty of a given quantity using mathematical formulas for the combination of errors. Variance propagation involves many considerations, and the choice of formulas for computing the uncertainty depends upon the functional relationships of the measurement parameters involved.

Verification Measurement. A quantitative remeasurement to verify an existing previously-reported measured value.

Warning Limits. Established values (quantity limits) for IDs which, when exceeded, require investigation and appropriate action. Note: For processing, production, and fabrication operations, warning limits are established with a 95 percent confidence level.

Working Standard. A reference material that has been sufficiently analyzed or characterized for internal use as a calibration or control standard, and where possible, is traceable to a national measurement base.

2.4 Concepts

At the Y-12 Plant, the function charged with administration of the MC&A system is organizationally so aligned as to not come under the direct supervision or control of the production function, even though a strong interface between the two functions is demanded. Guidelines for control and accountability are prescribed in DOE Order 5633.3B, "Control and Accountability of Nuclear Materials." Within the Y-12 Plant, these guidelines are implemented in the accountability procedures manual Y20 and a multitude of standard operating procedures (SOP's) that translate the necessary controls to the operating areas.

Great effort is made to convert the various accountable materials to a readily measurable and controllable state of an item so that at inventory time as little material as is absolutely necessary is newly measured and/or estimated. At inventory time, all scrap and/or salvage materials that are on hand in the operating areas is shipped to the salvage recovery MBA for measurement and eventual recovery. The newly measured material, at inventory time, is almost totally comprised of these salvage materials that have been processed to a homogeneous state, sampled, and then measured. Estimated inventory includes materials held up in air ducts, contained inside machines that are not dismantled, entrained in carbon molds and crucibles, held up in filters, etc.

From a philosophical standpoint, wastes, NOLs, and discards are measured conservatively (i.e., to be sure not to overstate these values).

To assure effective resolution of any control problems of enriched uranium above 20 percent ^{235}U, after each physical inventory, a review meeting is held. The review consists of representatives from operating areas, analytical services, statistical services, and nuclear material control functions.

The Y-12 Plant has, as a part of the NMC&A organization, an internal audit function that continually reviews from an MC&A perspective adherence to approved procedures, correctness of data flows, accuracy of measurements, and adequacy of the internal accounting system.

3.0 Brief History of Y-12 Plant Operation

3.1 Electromagnetic Process

Construction of the Y-12 Plant commenced in 1943 under the direction of the U.S. Army, Manhattan Engineer District. Originally, the purpose of the facility was the separation of the ^{235}U isotope utilizing the electromagnetic process. The first building was placed in operation approximately January 1944. Product from the whole operation was weapon grade SNM in the form of UF_4, and this product was shipped to Albuquerque for further processing.

During the construction and production period through December 31, 1946, the U.S. Army was in charge of the plant and product and little is known about the description, process, and inventory of the electromagnetic separation process. However, USAEC Survey #6, subject "Survey of Accounting Control Over Source and Fissionable Materials," Carbide and Carbon Chemicals Corporation, Y-12 Plant, Oak Ridge, Tennessee, dated January 8, 1948, provides information about the survey team, description of the plant, and review of the process. The following is from that report:

"A survey of the accounting control maintained over source and fissionable materials in the electromagnetic process plant at Oak Ridge, Tennessee, was completed December 15, 1947. Participating in the survey were W. J. Martin of the Clinton Production Division, Oak Ridge Directed Operations, and D. E. George, W. L. Ginkel, Ed Hall, and H. W. Norton of the Source and Fissionable Materials Accountability Branch, Division of Production.

In the electromagnetic separation process, charge material (UCl_4) is vaporized and ionized in a very high vacuum. The stream of ionized uranium atoms is accelerated and then subjected to a strong magnetic field. This field causes all charged uranium atoms to describe a curved path, with the ions of lesser mass (the ^{235}U isotope) describing a sharper curve than the ^{238}U isotope. At the ends of the area, the ^{235}U and ^{238}U can be collected in separate receptacles or "pockets".

Electromagnetic separation operations were designed and originally conducted as a two-stage process. Uranium with normal isotopic composition (0.705 percent ^{235}U) was fed to the Alpha or first stage plant. Product uranium from the Alpha plant contained 10 to 20 percent ^{235}U, and it was fed to the Beta or second stage plant. Product uranium from the Beta plant contained from 75 to 95 percent ^{235}U.

The Y-12 Alpha plant began separation of ^{235}U in the latter part of 1943. In May 1944, Alpha product was first used as feed for the newly completed Beta units. As soon as the K-25 Gaseous Diffusion Plant and the S-50 Thermal Diffusion Plant began producing in 1945, their products (uranium enriched in the ^{235}U isotope) were used as feed for the Y-12 Alpha plant in lieu of normal feed. Later, as the K-25 product became sufficiently enriched in ^{235}U, this product was used as feed for Y-12 Beta units, but both Alpha and Beta units continued in operation until September 1945 at which time the Alpha plant was placed in standby condition. During the latter part of 1946, it was demonstrated that the K-25 plant could safely enrich uranium to product level concentration; therefore, for reasons of economy, all Beta units (except one track for experimental purposes) were placed in standby condition in January 1947.

Under present status, the Y-12 plant is no longer engaged in producing uranium with a high concentration of ^{235}U but is primarily concerned with electromagnetic experimentation using normal uranium as feed. It is also engaged in chemical research and development work in connection with the atomic program.

The only remaining full-scale production operation in the Y-12 Plant is the product conversion process which is carried out in Building 9212. In this process, the highly enriched UF_6 product from K-25 is purified and converted to green salt (UF_4). This is accomplished by dissolving the UF_6 followed by multiple precipitation, calcination, and fluorination to UF_4. The process is entirely a chemical one with no change in the ^{235}U enrichment of the material. The UF_4 is placed in shipping containers and delivered to the AEC Y-12 representative for transfer to the USAEC Production Branch, Oak Ridge Directed Operations.

A new program, reduction of green salt to metal and fabrication of metal parts, formerly performed exclusively at Los Alamos, is now getting underway and may be in full operation early in 1948.

The plant is operated for the Atomic Energy Commission by the Carbide and Carbon Chemicals Corporation, in accordance with a cost-plus-fixed-fee contract administered by the Office of Oak Ridge Directed Operations. It is a large government-owned plant, occupying about 500 acres and containing about 170 buildings, most of which are now in standby condition. Present employment is about 2100 as opposed to about 21,000 when the plant was in full production."

The inventory and summary operations for the Alpha Plant (3.1.1) is provided for the period of operation 8-12-43 through 12-31-46. The total enriched production of the Alpha Plant, 855.6 kg U with 95.72 kg ^{235}U, were transferred to the Beta Plant as feed. The average assay of the 855.6 kg U was 11.19 percent ^{235}U. The MUF or ID totaled 40,441.0 kg U with 268.59 kg ^{235}U. The average assay of the 40,441.0 kg U was 0.66 percent ^{235}U.

The inventory and summary of operations for the Beta Plant (3.1.2) is shown for the period of operation 5-13-44 through 12-31-46. Product from K-25 as feed to the Beta Plant was 4,895,335 grams U at an average assay of 25.8 percent with 1,265,296 grams ^{235}U. Total transfers of highly enriched material were 1,114,121 grams U at an average assay of 93.9 percent with 1,045,697 grams ^{235}U. The MUF or ID was 483,553 grams U at an average assay of 23.5 percent with 113,852 grams ^{235}U.

The Alpha and Beta summaries, shown on pages 17 and 18, are essentially in the same format as they appeared in the original document (reference Section 9.0, "Source Documents," Number 80). The Alpha plant balance was originally reported in kilogram quantities and the Beta plant in grams. Process descriptions, acronyms, and codes are shown on page 16. The information shown on page 16 will assist the reader in understanding the terminology used over 50 years ago.

Electromagnetic Process Descriptions, Acronyms, and Codes

Alpha	First stage in the separation of ^{235}U isotope from normal uranium feed in the electromagnetic process. The Alpha product contained 10% to 20% ^{235}U.
Beta	Second or final stage in separation of ^{235}U from enriched uranium produced by the Alpha stage. The 10% to 20% ^{235}U was enriched up to 98.00% ^{235}U by the Beta process.
Cycles:	
700	Alpha Normal Uranium Cycle (.705% ^{235}U)
800	Alpha Product
900	Alpha Product
1000*	Early Beta Recycle Material (10.00-14.99% ^{235}U)
1100	Former Alpha Recycle in Beta (7.00-20.00% ^{235}U)
1200	700 Product Level Material
1300*	Former Beta Recycle Material (25.00-29.99% ^{235}U)
1700	Q Pocket Takeout
1800*	Q Pocket Takeout
1900	Product Level ^{235}U (90.00-94.99%)
R.S.W	Building 9212 Recycle - MBA 70
U.S.E.D	United States Engineering District
R Pocket Take-Out	90.00 to 94.99% ^{235}U Product
Q Pocket Take-Out	0.7% ^{235}U Product
E Pocket Take-Out	Fabricated Product
T	Code for Uranium Element
X	Code for Uranium Isotope
Xc	Weight Percent ^{235}U
TEC	Tennessee Eastman Corporation
USAEC	United States Atomic Energy Commission

*Cycles 1000, 1300, and 1800 were combined with 1700 cycle in November 1946.

SECRET

Inventory of Alpha Plant Uranium December 31, 1946
and Summary of Operations to December 31, 1946
(700, 800, and 900 Material)
(kg)

	1943			1944			1945			1946			Recapitulation 8-12-43 To 12-31-46		
	T	Xc	X	T	Xc	X	T	Xc	X	T	Xc	X	T	Xc	X
Beginning Inventory	None		None	7,507.0	0.71	53.60	75,859.5	0.71	541.64	None		None	None		None
Receipts															
From Mallinchrodt	4,535.1	0.71	32.39	'05,876.4	0.71	755.96	32,284.0	0.71	230.51	None		None	142,695.5	0.71	1,018.86
From Harshaw	None		None	19,874.2	0.71	141.90	24,253.1	0.71	173.17	None		None	44,127.3	0.71	315.07
From Fercleve	None		None	85.9	0.85	0.73	5,328.3	0.85	45.29	None		None	5,414.2	0.85	46.02
From Carbide & Carbon	None		None	None		None	14,152.5	1.11	157.47	99.2	1.44	1.43	14,251.7	1.11	158.90
From Rochester	1,736.3	0.71	12.39	None		None	None		None	None		None	1,736.3	0.71	12.39
From Berkeley	1,232.2	0.71	8.80	73.0	0.71	0.52	None		None	None		None	1,305.2	0.71	9.32
From U.S.E.D.	None		None	1,231.3	0.71	8.79	20,511.1	0.71	146.45	None		None	21,742.4	0.71	155.24
Salv. From Beta Cycles	None		None	None		None	1.8	1.99	0.04	None		None	1.8	1.99	0.04
Misc.	3.4	0.71	0.02	530.3	0.71	3.79	379.6	0.71	2.71	315.0	0.71	2.25	1,228.3	0.71	8.77
Total Receipts	7,507.0	0.71	53.60	'27,671.1	0.71	911.69	96,910.4	0.78	755.64	414.2	0.89	3.68	232,502.7	0.74	1,724.61
B. I. Plus Receipts	7,507.0	0.71	53.60	'35,178.1	0.71	965.29	172,769.9	0.75	1,297.28	414.2	0.89	3.68	232,502.7	0.74	1,724.61
Transfers Out															
Alpha Product - To Beta Plant	None		None	200.3	10.98	21.99	655.3	11.25	73.73	None		None	855.6	11.19	95.72
To Harshaw	None		None	6,387.9	0.71	45.61	10,037.1	0.71	71.66	None		None	16,425.0	0.71	117.27
To Fercleve	None		None	None		None	36.1	0.85	0.31	None		None	36.1	0.85	0.31
To Carbide & Carbon	None		None	None		None	2,126.6	0.97	20.68	None		None	2,126.6	0.97	20.68
To U.S.E.D.	None		None	:9,015.9	0.71	135.77	151,104.9	0.71	1,068.36	None		None	170,120.8	0.71	1,204.13
Miscellaneous	None		None	46.2	0.71	0.33	537.7	0.71	3.84	662.3	0.71	4.73	1,246.2	0.71	8.90
Inv. Adj. - Matl. Unaccounted For	None		None	33,668.3	0.65	219.95	8,272.2	0.71	58.70	-1,499.5	0.67	-10.06	40,441.0	0.66	268.59
Total Transfers Out	None		None	59,318.6	0.71	423.65	172,769.9	0.75	1,297.28	(837.2)	0.64	(5.33)	231,251.3	0.74	1,715.60
nding Inventory	7,507.0	0.71	53.60	'5,859.5	0.71	541.64	None		None	1,251.4	0.72	9.01	1,251.4	0.72	9.01

Minus Denotes Gain
(See page 16 for explanations of acronyms and codes.)

SECRET

3.1.1 Alpha Plant

Inventory of Alpha Plant Uranium December 31, 1946
and Summary of Operations to December 31, 1946
(700, 800, and 900 Material)
(kg)

	1943			1944			1945			1946			Recapitulation 8-12-43 To 12-31-4		
	T	Xc	X	T	Xc	X	T	Xc	X	T	Xc	X	T	Xc	
Beginning Inventory	None		None	7,507.0	0.71	53.60	75,859.5	0.71	541.64	None		None	None		
Receipts															
From Mallinchrodt	4,535.1	0.71	32.39	'05,876.4	0.71	755.96	32,284.0	0.71	230.51	None		None	142,695.5	0.71	1,01
From Harshaw	None		None	19,874.2	0.71	141.90	24,253.1	0.71	173.17	None		None	44,127.3	0.71	31
From Fercleve	None		None	85.9	0.85	0.73	5,328.3	0.85	45.29	None		None	5,414.2	0.85	4
From Carbide & Carbon	None		None	None		None	14,152.5	1.11	157.47	99.2	1.44	1.43	14,251.7	1.11	15
From Rochester	1,736.3	0.71	12.39	None		None	None		None	None		None	1,736.3	0.71	1
From Berkeley	1,232.2	0.71	8.80	73.0	0.71	0.52	None		None	None		None	1,305.2	0.71	
From U.S.E.D.	None		None	1,231.3	0.71	8.79	20,511.1	0.71	146.45	None		None	21,742.4	0.71	15
Salv. From Beta Cycles	None		None	None		None	1.8	1.99	0.04	None		None	1.8	1.99	
Misc.	3.4	0.71	0.02	530.3	0.71	3.79	379.6	0.71	2.71	315.0	0.71	2.25	1,228.3	0.71	
Total Receipts	7,507.0	0.71	53.60	'27,671.1	0.71	911.69	96,910.4	0.78	755.64	414.2	0.89	3.68	232,502.7	0.74	1,72
B. I. Plus Receipts	7,507.0	0.71	53.60	'35,178.1	0.71	965.29	172,769.9	0.75	1,297.28	414.2	0.89	3.68	232,502.7	0.74	1,72
Transfers Out															
Alpha Product - To Beta Plant	None		None	200.3	10.98	21.99	655.3	11.25	73.73	None		None	855.6	11.19	9
To Harshaw	None		None	6,387.9	0.71	45.61	10,037.1	0.71	71.66	None		None	16,425.0	0.71	11
To Fercleve	None		None	None		None	36.1	0.85	0.31	None		None	36.1	0.85	
To Carbide & Carbon	None		None	None		None	2,126.6	0.97	20.68	None		None	2,126.6	0.97	20
To U.S.E.D.	None		None	'9,015.9	0.71	135.77	151,104.9	0.71	1,068.36	None		None	170,120.8	0.71	1,20
Miscellaneous	None		None	46.2	0.71	0.33	537.7	0.71	3.84	662.3	0.71	4.73	1,246.2	0.71	8
Inv. Adj. - Matl. Unaccounted For	None		None	33,668.3	0.65	219.95	8,272.2	0.71	58.70	-1,499.5	0.67	-10.06	40,441.0	0.66	26
Total Transfers Out	None		None	59,318.6	0.71	423.65	172,769.9	0.75	1,297.28	(837.2)	0.64	(5.33)	231,251.3	0.74	1,715
Ending Inventory	7,507.0	0.71	53.60	'5,859.5	0.71	541.64	None		None	1,251.4	0.72	9.01	1,251.4	0.72	9

Minus Denotes Gain
(See page 16 for explanations of acronyms and codes.)

3.1.2 Beta Plant

Inventory of Beta Cycle Uranium December 31, 1946
And Summary of Operations Through December 31, 1946
(1000, 1100, 1200, and 1300 Recycles)
(gram)

	1944			1945			1946			Recapitulation 5-13-44 To 12-31-46		
	T	Xc	X	T	Xc	X	T	Xc	X	T	Xc	X
Beginning Inventory	None		None	73,287	11.0	8,045	649,281	24.5	159,268	None		None
Receipts												
From TEC Alpha Plant	200,343	11.0	21,992	655,257	11.3	73,730	None		None	855,600	11.2	95,722
From K-25 Plant	None		None	1,941,489	20.9	405,777	2,953,846	29.1	859,519	4,895,335	25.8	1,265,296
Beta Product From RSW (1900 Material)	None		None	242	91.7	222	552	78.6	434	794	82.6	656
Miscellaneous Receipts From U.S.E.D.	None		None	None		None	9	13.5	1	9	13.5	1
Crossover From Alpha Cycle (900 Material)	None		None	None		None	1,979	1.0	20	1,979	1.0	20
Crossover From Q Take-Out (1800 Material)	None		None	None		None	1,138	0.8	9	1,138	0.8	9
Total Receipts	200,343	11.0	21,992	2,596,988	18.5	479,729	2,957,524	29.1	859,983	5,754,855	23.7	1,361,704
Beginning Inventory Plus Receipts	200,343	11.0	21,992	2,670,275	18.3	487,774	3,606,805	28.3	1,019,251	5,754,855	23.7	1,361,704
Transfers Out												
R Pocket Take-Out (1900 Material)	12,416	73.1	9,071	245,997	90.9	223,691	855,708	95.0	812,935	1,114,121	93.9	1,045,697
Q Pocket Take-Out (1700 & 1800 Material)	81,586	0.6	473	1,105,815	0.3	3,344	2,043,800	0.6	11,864	3,231,201	0.5	15,681
Total E Pocket Take-Out	94,002	10.2	9,544	1,351,812	16.8	227,035	2,899,508	28.4	824,799	4,345,322	24.4	1,061,378
Shipments to K-25 Plant	None		None	409,417	12.3	50,180	216,531	26.2	56,628	625,948	17.1	106,808
Miscellaneous Shipments to U.S.E.D.	None		None	2,750	10.0	275	208	30.8	64	2,958	11.5	339
Salvage Transferred to Alpha Cycles	None		None	1,756	2.0	35	None		None	1,756	2.0	35
Discarded Salvage	None		None	None		None	13,909	25.7	3,568	13,909	25.7	3,568
Beta Product Returned to RSW (1900 Material)	None		None	None		None	13	92.3	12	13	92.3	12
Inv. Adjustment - Material Unaccounted For	33,054	13.3	4,403	255,259	20.0	50,981	195,240	29.9	58,468	483,553	23.5	113,852
Total Transfers Out	127,056	11.0	13,947	2,020,994	16.3	328,506	3,325,409	28.4	943,539	5,473,459	23.5	1,285,992
Ending Inventory	73,287	11.0	8,045	649,281	24.5	159,268	281,396	26.9	75,712	281,396	26.9	75,712

See page 16 for explanations of acronyms and codes.

3.2 Program and MC&A History

Tennessee Eastman was the original operating contractor, and their tenure ended in 1947 when the Carbide and Carbon Chemical Corporation assumed the operating role until April 1, 1984. At this time, Martin Marietta Energy Systems, Inc., was awarded the contract and has continued to the present. In May 1947, product from the gaseous diffusion enrichment operation at the Oak Ridge Gaseous Diffusion Plant (K-25) completely replaced the electromagnetic isotope separation process as feed for the Y-12 Plant operations, and weapon grade SNM metal first became a product of the plant in 1948.

During the tenure of Eastman, the need to maximize the utilization of available SNM assured strict accountability. The general structure of an SNM accounting system was established, and the concept of an MBA was used. The MC&A records system employed since operation by Carbide has seen a radical expansion of chemical processing flows, a radical expansion of levels of enriched uranium (segregated for accountancy), and addition of processing streams for nuclear materials other than uranium such as enriched lithium-6 and deuterium.

Governmental guidelines for control and accountability for SNM were first formalized as a complete system in a document titled "Bulletin GM-PRO-2," Serial No. 95, dated August 15, 1951. The stabilizing factors for GM-PRO-2 were two reviews directed initially toward SNM accounting systems and secondly toward measurement and inventory practices by Lybrand, Ross Bros., and Montgomery (a CPA firm), and Hydrocarbon Research, Inc. (technical consultants), respectively.

GM-PRO-2 was superseded in 1956 by AEC Manual Appendix 7401 which, after a series of title changes, was superseded in theory (not implementation) by an ERDA-6401 series. Currently, the DOE Order 5633.3A series titled "Control and Accountability of Nuclear Materials" provides the principles and guidelines to be used by DOE operations offices and their contractors. After formalized requirements were implemented, two specific reviews of the accountability program were made. In 1955, the general manager directed the appointment of a committee chaired by Dr. Marvin M. Mann of the AEC and made up of technical experts from DuPont, Union Carbide (K-25), General Electric Co. (Hanford), Los Alamos Scientific Laboratory (LASL), and Argonne National Laboratory. The purpose of this review was to determine whether the basic premises, organization, regulations, and procedures were sound, reasonable, and responsive to the needs of the AEC in light of the change in the Atomic Energy Act in 1954. The committee's report dated January 1956 concluded that the basic system was sound and generally appropriate to the material controlled, major problems were predominantly technical in nature, and solutions to the problems could and should be made within the existing organizational structure.

Studies by the Stanford Research Institute (SRI) for the Division of Nuclear Materials Management encompassed a wide variety of MC&A activities and control indicators employed by the AEC facilities involved with the commission's material flows. Results of the study were published in documents titled, "Review of AEC Nuclear Materials Management Systems," and "Statistical and Inventory Procedures Applied to Nuclear Materials Management," dated August 1962 and April 1966, respectively. The primary conclusion of the study was a need for a centralized, computerized information system that encompassed the overall MC&A analytical and managerial data needs.

As an outgrowth of the first SRI study, the Division of Nuclear Materials Management, AEC, Headquarters (HQ), sponsored a study to compare from a nuclear materials control standpoint, the highly enriched uranium operations at the Y-12 Plant and those at the Rocky Flats Plant. A very wide set of control parameters was evaluated, and in June 1963, the conclusions of the study were published. The study group found that the two operations were not comparable for evaluation of material unaccounted-for (MUF) quantities.

The MC&A efforts at the Y-12 Plant have evolved to accommodate the order of magnitude of changes in material flows as well as administrative reporting requirements to meet the government's various control needs as the state-of-the-art has permitted. Organizationally, the MC&A function was directed toward accountability records and attendant procedures until FY 1979 when specific efforts to establish an MC&A engineering group were initiated. This effort was accelerated in late FY 1979, and currently a permanent staff of professional level personnel are actively pursuing MC&A engineering. From 1945 until 1979, the MC&A engineering activities were addressed by production personnel.

Statistically, analysis of the various MC&A control indicators was performed by the statistical services function at the Y-12 Plant from the beginning through FY 1986. Beginning FY 1987, NMC&A added a statistician to the organization and at present has two statisticians on staff. The statistical effort previously done on control indicators is now being done by the NMC&A statisticians. However, the plant statistical services function continues to provide support for the measurement control program and consultant services.

4.0 History of Material Types

4.1 Enriched Uranium above 20 percent ^{235}U

The Y-12 Plant was constructed during World War II for the enrichment of ^{235}U by the electromagnetic separation process. This operation performed successfully and produced the uranium for the Hiroshima weapon.

However, the parallel method for enriching uranium (gaseous diffusion) proved to be much more efficient, and the Y-12 Operation was closed in early 1947.

At this same time, there was a desire to move the weapon's manufacturing operations from Los Alamos National Laboratory (LANL). Because of its uranium processing capabilities and the availability of buildings, Y-12 was chosen as the location for the enriched uranium metal processing site. Reduction of enriched uranium to metal and casting of rough shapes and fabrication of finished machine parts began in the spring of 1948. The level of activity remained small until the early 1950s, at which time the level of effort turned rapidly upward. Following the national decision to produce thermonuclear (hydrogen bomb) weapons, Y-12 was chosen as the site for enrichment and subsequent processing of lithium. The combination of enriched uranium and lithium into subassemblies was assigned to Y-12, and this was the beginning of the very extensive participation of Y-12 into the nuclear weapons program.

Table III
Annual Summary of Above 20 Percent ^{235}U ID
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
CY 1947	- 22	- 3	- 22	- 3
CY 1948	0[5]	1	- 22	- 2
CY 1949	2	5	- 20	3
CY 1950	- 1	- 1	- 21	2
CY 1951 (6 mo.)	- 1	- 0	- 22	2
FY 1952	1	7	- 20	9
FY 1953	0	1	- 20	10
FY 1954	8	8	- 12	18
FY 1955	18	8	6	26
FY 1956	26	31	32	57
FY 1957	29	40	61	97
FY 1958	64	61	125	158
FY 1959	108	124	233	282
FY 1960	84	65	317	347
FY 1961	52	93	369	440
FY 1962	103	105	472	545
FY 1963	- 84	- 106	388	439
FY 1964	111	162	499	601
FY 1965	- 28	- 25	471	576
FY 1966	90	102	561	678
FY 1967	- 81	- 67	480	611
FY 1968	5	12	485	623
FY 1969	- 19	- 11	466	612
FY 1970	43	62	509	674
FY 1971	- 31	- 13	478	661
FY 1972	111	91	589	752
FY 1973	31	- 17	620	735
FY 1974	- 17	31	603	766
FY 1975	12	21	615	787
FY 1976	20	7	635	794
FY 1976A (3 mo.)	8	31	643	825
FY 1977	17	- 16	660	809
FY 1978	- 9	- 3	651	806
FY 1979	47	56	698	862
FY 1980	- 4	4	694	866
FY 1981	68	85	762	951
FY 1982	16	7	778	958
FY 1983	25	32	803	990
FY 1984	33	24	836	1,014
FY 1985	- 48	- 29	788	985
FY 1986	76	78	864	1,063
FY 1987[6]	- 70	- 63	794	1,000
FY 1988	- 8	8	786	1,008
FY 1989	- 19	19	767	1,027
FY 1990	8	- 6	775	1,021
FY 1991	- 45	- 34	730	987
FY 1992	- 12	- 14	718	973
FY 1993	24	20	742	993

Minus denotes gain.

[5] Zero represents transactions less than 500 grams.

[6] Strike - June 20 through October 10, 1987.

Table IV
Annual Enriched Uranium Above 20 Percent ^{235}U Discards to Burial Ground
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
CY 1947	-[7]	-	-	-
CY 1948	-	-	-	-
CY 1949	0[8]	0	0	0
CY 1950	0	0	0	0
CY 1951 (6 mo.)	0	0	0	0
FY 1952	0	0	0	0
FY 1953	1	1	1	1
FY 1954	4	4	5	5
FY 1955	2	2	7	7
FY 1956	4	3	11	10
FY 1957	12	11	23	21
FY 1958	15	14	38	35
FY 1959	53	49	91	84
FY 1960	37	34	128	118
FY 1961	29	27	157	145
FY 1962	25	23	182	168
FY 1963	33	31	215	199
FY 1964	38	35	253	234
FY 1965	34	27	287	261
FY 1966	54	32	341	293
FY 1967	25	22	366	315
FY 1968	37	34	403	349
FY 1969	28	20	431	369
FY 1970	34	25	465	394
FY 1971	30	26	495	420
FY 1972	39	35	534	455
FY 1973	30	24	564	479
FY 1974	22	18	586	497
FY 1975	20	15	606	512
FY 1976	13	9	619	521
FY 1976A (3 mo.)	3	3	622	524
FY 1977	39[9]	34[9]	661	558
FY 1978	10	7	671	565
FY 1979	7	5	678	570
FY 1980	8	6	686	576
FY 1981	8	6	694	582
FY 1982	14	11	708	593
FY 1983	38[10]	32[10]	746	625
FY 1984	18	15	764	640
FY 1985	19	16	783	656
FY 1986	15	12	798	668
FY 1987	9	7	807	675
FY 1988	14	12	821	687
FY 1989	15	12	836	699

Explanation of Footnotes 9 and 10: At the direction of DOE-ORO, two offsite receipts of HEU were charged directly to the burial ground [VZG] bypassing Y-12 Plant [FZB]. Since these receipts did not follow the usual accounting procedure, they are included in Table IV but not in Table II.

---

[7] Dash represents no transactions.

[8] Zero represents transactions less than 500 grams.

[9] HEU from United Nuclear Corporation (FBY-VZG-1 through -6) containing 30 kg U and 28 kg ^{235}U was disposed to the Y-12 burial ground in FY 1977.

[10] HEU from United Nuclear Corporation, Wood River Junction, Rhode Island (ZWT-VZG-1 through -496) containing 16 kg U and 14 kg ^{235}U was disposed to the Y-12 burial ground in FY 1983.

SECRET

Table IV (continued)
Annual Enriched Uranium Above 20 Percent ^{235}U Discards to Burial Ground
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
FY 1990	6	5	842	705
FY 1991	3	3	845	708
FY 1992[11]	0	0	845	708
FY 1993	-	-	845	708
FY 1994	-	-	845	708

[11] Burial Ground was closed July 1, 1992. Since then, discards are held for storage awaiting disposal.

SECRET

Table V
Annual Enriched Uranium Above 20 Percent ^{235}U Discards to Sanitary/Storm Sewer[12]
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
CY 1947	-[13]	-	-	-
CY 1948	-	-	-	-
CY 1949	-	-	-	-
CY 1950	-	-	-	-
CY 1951 (6 mo.)	-	-	-	-
FY 1952	-	-	-	-
FY 1953	0[14]	0	0	0
FY 1954	0	0	0	0
FY 1955	0	0	0	0
FY 1956	0	0	0	0
FY 1957	0	0	0	0
FY 1958	0	0	0	0
FY 1959	9	8	9	8
FY 1960	9	8	18	16
FY 1961	10	9	28	25
FY 1962	21	13	49	38
FY 1963	14	13	63	51
FY 1964	14	12	77	63
FY 1965	24	14	101	77
FY 1966	13	11	114	88
FY 1967[15]	11	10	125	98
FY 1968	12	10	137	108
FY 1969	13	11	150	119
FY 1970	10	9	160	128
FY 1971	12	10	172	138
FY 1972	14	13	186	151
FY 1973	11	10	197	161
FY 1974	7	7	204	168
FY 1975	8	8	212	176
FY 1976	5	4	217	180
FY 1976A (3 mo.)	1	1	218	181
FY 1977	5	4	223	185
FY 1978	3	3	226	188
FY 1979	3	2	229	190
FY 1980	3	2	232	192
FY 1981	11	10	243	202
FY 1982	6	5	249	207
FY 1983	7	7	256	214
FY 1984	5	4	261	218
FY 1985	1	0	262	218
FY 1986	0	0	262	218
FY 1987	0	0	262	218
FY 1988	0	0	262	218
FY 1989	0	0	262	218

12 These totals include values in Table VI.

13 Dash represents no transactions.

14 Zero represents transactions less than 500 grams.

15 Discards to Sanitary sewer were separated beginning FY 1967 but continued to be included in the Storm Sewer Report.

Table V (continued)
Annual Enriched Uranium Above 20 Percent ^{235}U Discards to Sanitary/Storm Sewer
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
FY 1990	0	0	262	218
FY 1991	0	0	262	218
FY 1992	0	0	262	218
FY 1993	0	0	262	218
FY 1994	1	1	263	219

SECRET

Table VI

Annual Enriched Uranium Above 20 Percent ^{235}U Discards to Sanitary Sewer Only[16]

(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
FY 1967	2	2	2	2
FY 1968	2	2	4	4
FY 1969	2	2	6	6
FY 1970	2	2	8	8
FY 1971	2	2	10	10
FY 1972	2	2	12	12
FY 1973	2	2	14	14
FY 1974	1	1	15	15
FY 1975	2	2	17	17
FY 1976	1	1	18	18
FY 1976A (3 mo.)	0[17]	0	18	18
FY 1977	0	0	18	18
FY 1978	0	0	18	18
FY 1979	0	0	18	18
FY 1980	0	0	18	18
FY 1981	0	0	18	18
FY 1982	0	0	18	18
FY 1983	0	0	18	18
FY 1984	0	0	18	18
FY 1985	0	0	18	18
FY 1986	0	0	18	18
FY 1987	0	0	18	18
FY 1988	0	0	18	18
FY 1989	0	0	18	18
FY 1990	0	0	18	18
FY 1991	0	0	18	18
FY 1992	0	0	18	18
FY 1993	0	0	18	18
FY 1994	0	0	18	18

16 These totals are included in Table V.

17 Zero represents ~~transactions less than 500 grams.~~

SECRET

Table VII
Annual Enriched Uranium Above 20 Percent ^{235}U Discards to S-3 Pond
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
FY 1972[18]	9	7	9	7
FY 1973	5	4	14	11
FY 1974	6	3	20	14
FY 1975	4	3	24	17
FY 1976	4	2	28	19
FY 1976A (3 mo.)	1	1	29	20
FY 1977	2	1	31	21
FY 1978	1	1	32	22
FY 1979	2	2	34	24
FY 1980	3	3	37	27
FY 1981	5	5	42	32
FY 1982	6	5	48	37
FY 1983	5	4	53	41
FY 1984	3	3	56	44
FY 1985[19]	0[20]	0	56	44
FY 1986	-[21]	-	56	44
FY 1987	-	-	56	44
FY 1988	-	-	56	44
FY 1989	-	-	56	44
FY 1990	-	-	56	44
FY 1991	-	-	56	44
FY 1992	-	-	56	44
FY 1993	-	-	56	44
FY 1994	-	-	56	44

18 Prior to FY 1972, S-3 Pond values were combined with burial ground totals.

19 The S-3 Pond at Y-12 was officially closed September 30, 1984.

20 Zero represents transactions less than 500 grams.

21 Dash represents no transactions.

Table VIII
Annual Enriched Uranium Above 20 Percent ^{235}U Discards to Track-out
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
FY 1956	0[22]	0	0	0
FY 1957	0	0	0	0
FY 1958	0	0	0	0
FY 1959	0	0	0	0
FY 1960	0	0	0	0
FY 1961	0	0	0	0
FY 1962	3	3	3	3
FY 1963	3	3	6	6
FY 1964	2	2	8	8
FY 1965	3	3	11	11
FY 1966	5	4	16	15
FY 1967	5	4	21	19
FY 1968	5	4	26	23
FY 1969	4	3	30	26
FY 1970	4	3	34	29
FY 1971	3	2	37	31
FY 1972	3	2	40	33
FY 1973	5	3	45	36
FY 1974	4	3	49	39
FY 1975	6	5	55	44
FY 1976	5	4	60	48
FY 1976A (3 mo.)	1	1	61	49
FY 1977	5	4	66	53
FY 1978	5	4	71	57
FY 1979	5	4	76	61
FY 1980	6	5	82	66
FY 1981	5	4	87	70
FY 1982	6	4	93	74
FY 1983	6	5	99	79
FY 1984	6	5	105	84
FY 1985	6	5	111	89
FY 1986	7	5	118	94
FY 1987	5	4	123	98
FY 1988	7	6	130	104
FY 1989	1	1	131	105
FY 1990	1	1	132	106
FY 1991	1	1	133	107
FY 1992	1	1	134	108
FY 1993	0	0	134	108
FY 1994	0	0	134	108

22 Zero represents transactions less than 500 grams.

Table IX

Annual Enriched Uranium Above 20 Percent ^{235}U Discards to Atmosphere/Stacks

(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
FY 1956[23]	8	3	8	3
FY 1957	7	3	15	6
FY 1958	7	4	22	10
FY 1959	5	5	27	15
FY 1960	8	7	35	22
FY 1961	6	5	41	27
FY 1962	6	5	47	32
FY 1963	9	8	56	40
FY 1964	5	4	61	44
FY 1965	3	2	64	46
FY 1966	3	2	67	48
FY 1967	1	1	68	49
FY 1968	0[24]	0	68	49
FY 1969	3	2	71	51
FY 1970	3	2	74	53
FY 1971	4	4	78	57
FY 1972	6	6	84	63
FY 1973	9	9	93	72
FY 1974	3	3	96	75
FY 1975	2	1	98	76
FY 1976	2	1	100	77
FY 1976A (3 mo.)	1	0	101	77
FY 1977	1	1	102	78
FY 1978	1	1	103	79
FY 1979	2	1	105	80
FY 1980	1	1	106	81
FY 1981	2	2	108	83
FY 1982	2	2	110	85
FY 1983	2	1	112	86
FY 1984	2	2	114	88
FY 1985	2	1	116	89
FY 1986	2	2	118	91
FY 1987	1	1	119	92
FY 1988	2	1	121	93
FY 1989	2	2	123	95
FY 1990	1	1	124	96
FY 1991	1	1	125	97
FY 1992	0	0	125	97
FY 1993	1	1	126	98
FY 1994	1	0	127	98

[23] Transactions for stacks were first reported in FY 1956.

[24] Zero represents transactions less than 500 grams.

4.1.2 Trends and Interpretations

Six distinct historical periods can be envisioned as segregating the factors that affected the reported IDs, and these periods are discussed below.

a. **Period CY 1947 through FY 1954 (12 kg uranium gain)**

In general, the IDs and the throughput were small. Materials with a variety of enrichments were being processed and most of this material was salvage from the electromagnetic process. Enrichment of the material was assumed when it was introduced into the salvage operations. Subsequent to processing the materials to a point where good samples could be obtained, it was frequently found that the originally assumed enrichment was in error; and no back calculations were made to correct the situation. It is obvious from the throughput that the production situation differs radically from the present.

b. **Period FY 1955 through FY 1957 (73 kg uranium deficiency)**

This period was one of transition when new processes were being developed for the production operations. Construction was initiated on

and many of the new systems were used for the first time in production.

No firm basis was available for estimation of process losses, and the equipment holdup was not known. Throughput increased rapidly since the last building of the Oak Ridge Gaseous Diffusion Plant came on stream in November 1954, and the Portsmouth Diffusion Plant achieved full production in February 1956.

As experience was gained and state-of-the-art measurements introduced, estimates of holdup as well as process losses were made. The measurements of these normal operational losses in retrospect appear crude but were made using the best means then available. The policy of conservatively stating losses was in existence at that time.

c. **Period FY 1958 through FY 1962 (411 kg uranium deficiency)**

caused many unacceptable fluctuations in monthly NM ID values. As a result, in 1959 a long-term committee, the Product Diversion Control Group, was established to determine the causes of the IDs and how to prevent their recurrence with special attention being directed to waste streams. This committee found several previously unidentified waste streams and found that practically all previously identified waste streams had been underestimated by 10 percent or more. As in the earlier days, no back corrections were made since they could not influence then current performance. Two examples of process losses that had been previously underestimated were a solution discard and discards of contaminated scrap. The solution discard had been estimated as being from 100 to 300 grams (g) uranium per month, and actual measurements invoked by committee showed the value to be in the order of 3,900 g uranium per month. The contaminated scrap metal for a two and one-half year period was assigned a discard value of from 13 to 15 kg uranium, but extensive measurements showed that the actual discard value should have been more like 145 kg uranium. A stream that was considered inconsequential was the sanitary sewers. The committee at the time of their investigation found this stream contained over 270 g uranium per month.

In addition to the above, there are at least two areas where some undetected losses occurred, and values either could not be generated or no effort was made to backfit values discarded. In the system for reducing UF_6 to UF_4 (Dry Chemistry Area, MBA 72) leaks from the system were either detected by a then state-of-the-art radiation detector or by discovery of UO_2F_2 in the chemical traps on the vent system, but small leaks could evade the system.

Such spilling was not noticed during the earlier operation; and once it was discovered to occur, no attempt was made to estimate the SNM discarded with that heat treating oil.

In summary, evaluating the results of the committee's findings and applying them to the available recor[illegible]r the FY 1957 through FY 1962 time period leads to the conclusion th[illegible]e actual discards for the period were underestimated by from 350 [illegible]00 kg uranium. It should be remembered that determinations were generally made in terms of uranium with an assumed enrichment.

d. **Period FY 1963 through FY 1976 (163 kg uranium deficiency)**

The plant ceased receiving UF_6 and began receiving SNM from retired weapons. Also, two large reactor related projects were injected into the overall production operation.

A Lawrence Livermore Laboratory fast reactor project titled Super Kukla utilized circular plates of 20 percent enriched SNM that had a diameter of about 30 inches. Because of the physical size of these plates, they were cast and machined in a foundry normally used for depleted uranium. Turnings from the machining operation were briquetted and used as part of a subsequent casting charge. Efforts were made to segregate the flows, but since depleted machine turnings were also briquetted and recast in this area, eventually crossovers between the flows occurred. It is estimated that between 100 and 120 kg of the Super Kukla materials were lost to the flow, and at the time, inventory records were not corrected to show the crossover.

Production of a fuel element called Rover involved an extrusion of carbon loaded with beads containing uranium. Total throughput for this flow at the Y-12 Plant was 9,372 kg uranium, and the total ID for this flow was 247 kg or approximately 2.6 percent. The reactor designers were concerned with relative content of SNM along the length of the elements rather than precise SNM content; often poor control of the material was maintained. For example, test elements were sawed in half axially and the halves returned to Y-12 without the saw dust. No accounting was made of losses during testing. Sampling of Rover salvage batches was inadequate. Most of the uranium in reject fuel elements was recovered by private enterprise with some recovered values exceeding the shippers values, and the uranium in irradiated fuel elements was still to be recovered in 1976. While it is probable that the 247 kg deficiency is too high, no real means exists for a better closure of the balance.

e. **Period FY 1976A through FY 1983 (168 kg uranium deficiency)**

Two out-of-control ID deficiencies were experienced during this period (May 1980 and August 1981); and, after a clean-out inventory, both were resolved and off-setting ID gains recorded. However, an overall explanation to ameliorate the 134 kg deficiency is not readily available. During FY 1979, the total ID was a deficiency of 47 kg uranium; and for FY 1981, the total was another deficiency of 68 kg uranium.

Long-term trends have shown that the usual ID situation has been for the salvage and recovery operation to experience an ID gain, for the machining operation to experience an ID gain, and the casting operation to generally experience an ID deficiency nearly equal in magnitude to the ID gains in the other two areas. This relationship has been accepted because the salvage recovery operation recovers large quantities of hard-to-measure salvage (skull oxide) from casting, and sampling methods used to generate values for crediting casting with the uranium shipped have been understood to bias the material content low. Thus, the salvage and recovery operation would find more SNM when the material was actually recovered than they were charged with. Also, casting receives oxidized SNM turnings as 100 percent metal from machining for remelt and, while the ratio of oxide is small, it is not pure metal.

With the two out-of-control ID deficiencies in May 1980 and August 1981, the expected gain of SNM in the salvage and recovery operation did not occur. These IDs attracted much attention including that of top management in the Union Carbide Nuclear Division; and as a result of ensuing investigations, the Enriched Uranium Recovery Improvements (EURI) budgetary line item was initiated.

As an item of interest, in more recent periods a system of nondestructive assay (NDA) equipment has been used to measure the salvage materials, including the skull oxide material being transferred from casting to recovery. This equipment measures the total content of the container, and it is felt that the values are more representative than those gained from wet chemical analysis of a heterogeneous sample. Since the NDA values have been used, the casting ID has been consistently very low with some ID gains along with the expected deficiencies. Also, in later periods, factors to correct for the oxide on the machine turnings were used in the flow of chips from machining to casting.

f. **Period FY 1984 through FY 1994**

Most of the UF_4 produced was from process residues accumulated in the NMSSS Warehouse from outside sources rather than current production. By the end of FY 1992, the Y-12 mission was primarily storage of residue from various sites, cleanup of the existing plant site, and to accept retired weapons for storage and disassembly.

The drastic decrease in production had a positive effect on the ID. For the eleven-year period, FY 1984 through FY 1994, the annual ID showed six gains and five deficiencies. Some apparent reasons for the large number of gains was the monthly cleanup, without the presence of large quantities of routine salvage generated from production of weapons parts, and tear down and cleanup of old equipment and facilities.

During the period CY 1947 through FY 1994, the largest cumulative uranium element ID loss in a year was in FY 1986 at 864 kg.

g. **Summary**

Much of the cumulative total SNM ID since 1947 can be explained by known measurement errors that have been quantified. There are instances in the early days where such errors were known to exist, but no effort was made to quantify the errors on a back-fit basis. Measurement capabilities for evaluating waste streams and other heterogeneous materials have greatly improved in recent years, and the Y-12 Plant is keeping abreast of the state-of-the-art. Inventory frequency for enriched uranium above 20 percent ^{235}U was changed from monthly to bi-monthly effective 10-1-92.

4.1.3 Incidents

Over the years, there have been several unusual incidents where identifiable SNM items have been misplaced or reported missing at the Y-12 Plant. Also, there have been instances where the monthly ID was out of the established control limits. For these instances, the appropriate notifications were made to the DOE (or predecessor) organizations and subsequently to the Federal Bureau of Investigation as required.

In all of these incidents, an internal audit or tracking effort was conducted by the Y-12 Plant personnel followed by a subsequent investigation by the ORO MC&A Branch personnel.

A typical unusual incident may consist of a missing fuel pin (approximately 2 g), an accidental release of kg quantities of SNM to the sewer or atmosphere, a monthly ID out of control, breach of physical barriers, or an excessive S/R difference.

The investigations and reviews of unusual incidents performed by the Y-12 Plant have never indicated any evidence of unauthorized removal or possession, gross negligence, or unauthorized use of material.

As mentioned above, the incidents may vary in significance and quantities. Probably the most notable incident at the Y-12 Plant occurred in November 1958. This consisted of a 284 kg ID deficiency of product level uranium (93 percent ^{235}U) in Salvage Extraction MBA 77. After extensive investigations by Y-12 personnel, the DOE-ORO MC&A Branch Office, and the AEC HQ NMC personnel, it was concluded that the ID was a result of a combination of errors in computation of inventories and mathematical errors regarding material holdup in the salvage recovery system.

4.2 Throughput and ID History for Enriched Uranium below 20 percent ^{235}U

The first known accountability records for enriched uranium below 20 percent ^{235}U are dated CY 1947. At that time, the product had been produced by the electromagnetic process at Y-12. Subsequent to CY 1947, the below 20 percent ^{235}U product was produced by the diffusion plants.

In the early years, from 1947 to mid 1960s, most of the production of below 20 percent ^{235}U was salvage recovery from outside customers including Westinghouse, K-25, Paducah Gaseous Diffusion Plant (PGDP), and General Electric. The product was shipped from Y-12 as compounds.

The first major break for salvage recovery occurred in the early to mid-1950s as a result of a power failure at K-25. Tons of salvage were shipped to Y-12 for recovery.

In the late 1950s, Building 9211 was the site of a production program converting K-25 Hex to $U0_3$ for Babcock & Wilcox (B&W). The $U0_3$ was subsequently transferred to Building 9998, H-1 Foundry, and converted to $U0_2$. The $U0_2$ was packaged and shipped to B&W

for reactor fuel. The assay range was approximately 2 to 4 percent ^{235}U. Also during this period, Fernald shipped tons of slag, liner, sump cake, etc., to Y-12 for recovery which was converted to U_3O_8 and subsequently shipped to K-25 on AEC 101s, presently identified as Form 741, for feed. The assay of this program was approximately .94 percent ^{235}U. This material was processed in Building 9211.

Part of the Kukla reactor material produced by Y-12 was below 20 percent ^{235}U or more specifically about 19.90 percent ^{235}U. Most of the production was accomplished in June 1964 to August 1964. From the early 1960s to early 1970s, a process was in effect to convert above 20 percent ^{235}U excess weapons to U_3O_8. The U_3O_8 was shipped to Portsmouth for storage.

4.2.1. Data

The annual enriched uranium below 20 percent ^{235}U throughput is shown in Table X for the period FY 1977 through FY 1994. Both element and isotope values are shown for each year . Table XI shows annual totals for shipments, EI, and ID since FY 1977. Table XII shows an annual summary and cumulative to date (CY 1947 through FY 1994) for ID below 20 percent ^{235}U. Tables XIII through XVI give annual totals and cumulative amounts of NOLs by disposal including burial ground, sanitary and storm sewer, S-3 Pond, and atmosphere discards.

Table XII

Annual Summary of Below 20 Percent ^{235}U ID

(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
CY 1947	1	- 0	1	- 0
CY 1948	- 1	- 0	0	- 0
CY 1949	- 1	- 0	- 1	- 0
CY 1950	- 1	- 0	- 2	- 0
CY 1951 (6 mo.)	- 9	- 0	- 11	- 0
FY 1952	- 2	1	- 13	1
FY 1953	- 21	0	- 34	1
FY 1954	1	0	- 33	1
FY 1955	2	- 0	- 31	1
FY 1956	- 4	2	- 35	3
FY 1957	4	- 1	- 31	2
FY 1958	462	6	431	8
FY 1959	295	14	726	22
FY 1960	33	1	759	23
FY 1961	- 10	9	749	32
FY 1962	- 85	- 2	664	30
FY 1963	- 204	5	460	35
FY 1964	24	22	484	57
FY 1965	- 0[27]	- 0	0	57
FY 1966	10	1	494	58
FY 1967	- 2	- 7	492	51
FY 1968	30	0	522	51
FY 1969	3	- 13	525	38
FY 1970	- 1	- 0	524	38
FY 1971	- 3	- 0	521	38
FY 1972	16	1	537	39
FY 1973	- 27	- 1	510	38
FY 1974	- 1	- 0	509	38
FY 1975	- 1	- 0	508	38
FY 1976	1	0	509	38
FY 1976A (3 mo.)	0	0	509	38
FY 1977	17	1	526	39
FY 1978	2	0	528	39
FY 1979	0	0	528	39
FY 1980	4	- 0	532	39
FY 1981	0	- 0	532	39
FY 1982	3	- 5	535	34
FY 1983	2	4	537	38
FY 1984	- 2	2	535	40
FY 1985	3	1	538	41
FY 1986	- 2	- 0	536	41
FY 1987[28]	- 1	- 0	535	41
FY 1988	2	0	537	41
FY 1989	1	1	538	42
FY 1990	1	0	539	42
FY 1991	- 87	- 0	452	42
FY 1992	0	0	452	42
FY 1993	- 40	- 2	412	40

Minus denotes gain.

[27] Zero represents transactions less than 500 grams.

[28] Strike - June 20, 1987 through October 10, 1987.

Table XIII
Annual Enriched Uranium Below 20 Percent ^{235}U Discards to Burial Ground
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
CY 1947	40	0	40	0
CY 1948	70	1	110	1
CY 1949	45	0	155	1
CY 1950	11	0	166	1
CY 1951 (6 mo.)	26	0	192	1
FY 1952	57	1	249	2
FY 1953	17	3	266	5
FY 1954	1	0	267	5
FY 1955	2	0	269	5
FY 1956	99	2	368	7
FY 1957	183	4	551	11
FY 1958	5,051	50	5,602	61
FY 1959	1,274	16	6,876	77
FY 1960	2,044	28	8,920	105
FY 1961	277	6	9,197	111
FY 1962	173	6	9,370	117
FY 1963	171	12	9,541	129
FY 1964	42	6	9,583	135
FY 1965	2	0	9,585	135
FY 1966	72	8	9,657	143
FY 1967	1	0	9,658	143
FY 1968	0[29]	0	9,658	143
FY 1969	1	0	9,659	143
FY 1970	1	0	9,660	143
FY 1971	0	0	9,660	143
FY 1972	0	0	9,660	143
FY 1973	0	0	9,660	143
FY 1974	0	0	9,660	143
FY 1975	1	0	9,661	143
FY 1976	0	0	9,661	143
FY 1976A (3 mo.)	0	0	9,661	143
FY 1977	0	0	9,661	143
FY 1978	0	0	9,661	143
FY 1979	0	0	9,661	143
FY 1980	0	0	9,661	143
FY 1981	0	0	9,661	143
FY 1982	0	0	9,661	143
FY 1983	0	0	9,661	143
FY 1984	0	0	9,661	143
FY 1985	0	0	9,661	143
FY 1986	0	0	9,661	143
FY 1987	0	0	9,661	143
FY 1988	0	0	9,661	143
FY 1989	0	0	9,661	143
FY 1990	0	0	9,661	143
FY 1991	0	0	9,661	143
FY 1992	0	0	9,661	143
FY 1993	0	0	9,661	143
FY 1994	0	0	9,661	143

[29] Zero represents transactions less than 500 grams.

Table XIV
Annual Enriched Uranium Below 20 Percent ^{235}U Discards to Sanitary/Storm Sewer
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
CY 1947	0[30]	0	0	0
CY 1948	0	0	0	0
CY 1949	45	0	45	0
CY 1950	0	0	45	0
CY 1951 (6 mo.)	7	1	52	1
FY 1952	3	0	55	1
FY 1953	1	0	56	1
FY 1954	1	0	57	1
FY 1955	5	1	62	2
FY 1956	7	1	69	3
FY 1957	18	1	87	4
FY 1958	1,291	13	1,378	17
FY 1959	1,556	9	2,934	26
FY 1960	3,257	33	6,191	59
FY 1961	48	2	6,239	61
FY 1962	1	0	6,240	61
FY 1963	4	0	6,244	61
FY 1964	0	0	6,244	61
FY 1965	5	1	6,249	62
FY 1966	5	1	6,254	63
FY 1967	0	0	6,254	63
FY 1968	0	0	6,254	63
FY 1969	0	0	6,254	63
FY 1970	0	0	6,254	63
FY 1971	0	0	6,254	63
FY 1972	0	0	6,254	63
FY 1973	0	0	6,254	63
FY 1974	0	0	6,254	63
FY 1975	0	0	6,254	63
FY 1976	0	0	6,254	63
FY 1976A (3 mo.)	0	0	6,254	63
FY 1977	0	0	6,254	63
FY 1978	0	0	6,254	63
FY 1979	0	0	6,254	63
FY 1980	0	0	6,254	63
FY 1981	0	0	6,254	63
FY 1982	0	0	6,254	63
FY 1983	0	0	6,254	63
FY 1984	0	0	6,254	63
FY 1985	0	0	6,254	63
FY 1986	0	0	6,254	63
FY 1987	0	0	6,254	63
FY 1988	0	0	6,254	63
FY 1989	0	0	6,254	63
FY 1990	0	0	6,254	63
FY 1991	0	0	6,254	63
FY 1992	-[31]	-	6,254	63
FY 1993	-	-	6,254	63
FY 1994	-	-	6,254	63

30 Zero represents transactions less than 500 grams.

31 Dash represents no transactions.

Table XV
Annual Enriched Uranium Below 20 Percent ^{235}U Discards to S-3 Pond
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
FY 1972[32]	4	0	4	0
FY 1973	1	0	5	0
FY 1974	0[33]	0	5	0
FY 1975	1	0	6	0
FY 1976	0	0	6	0
FY 1976A (3 mo.)	1	0	7	0
FY 1977	2	0	9	0
FY 1978	2	0	11	0
FY 1979	2	0	13	0
FY 1980	4	0	17	0
FY 1981	4	0	21	0
FY 1982	2	0	23	0
FY 1983	2	0	25	0
FY 1984[34]	0	0	25	0
FY 1985	-	-	25	0
FY 1986	-	-	25	0
FY 1987	-	-	25	0
FY 1988	-	-	25	0
FY 1989	-	-	25	0
FY 1990	-	-	25	0
FY 1991	-	-	25	0
FY 1992	-	-	25	0
FY 1993	-	-	25	0
FY 1994	-	-	25	0

[32] Prior to FY 1972, S-3 Pond values were combined with burial ground totals.

[33] Zero represents transactions less than 500 grams.

[34] The S-3 Pond at Y-12 was officially closed September 30, 1984.

Table XVI

Annual Enriched Uranium Below 20 Percent ^{235}U Discards to Atmosphere/Stacks

(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
FY 1956[35]	-[36]	-	-	-
FY 1957	-	-	-	-
FY 1958	-	-	-	-
FY 1959	23[37]	1	23	1
FY 1960	-	-	23	1
FY 1961	-	-	23	1
FY 1962	-	-	23	1
FY 1963	-	-	23	1
FY 1964	-	-	23	1
FY 1965	-	-	23	1
FY 1966	-	-	23	1
FY 1967	-	-	23	1
FY 1968	-	-	23	1
FY 1969	-	-	23	1
FY 1970	-	-	23	1
FY 1971	-	-	23	1
FY 1972	-	-	23	1
FY 1973	-	-	23	1
FY 1974	-	-	23	1
FY 1975	-	-	23	1
FY 1976	-	-	23	1
FY 1976A (3 mo.)	-	-	23	1
FY 1977	-	-	23	1
FY 1978	-	-	23	1
FY 1979	-	-	23	1
FY 1980	-	-	23	1
FY 1981	-	-	23	1
FY 1982	-	-	23	1
FY 1983	-	-	23	1
FY 1984	-	-	23	1
FY 1985	-	-	23	1
FY 1986	-	-	23	1
FY 1987	-	-	23	1
FY 1988	-	-	23	1
FY 1989	-	-	23	1
FY 1990	-	-	23	1
FY 1991	-	-	23	1
FY 1992	-	-	23	1
FY 1993	-	-	23	1
FY 1994	-	-	23	1

35 Transactions for stacks were first reported in FY 1956.

36 Dash represents no transactions.

37 This amount was an inadvertent release of uranium hexafluoride to the atmosphere from processing 3 and 4 percent ^{235}U.

4.2.2 Trends and Interpretations

Originally Buildings 9211 and 9206 were used for salvage recovery and production of low enriched ^{235}U. Since Building 9212 processed high enriched ^{235}U, it was prudent to keep the materials separate as much as possible because of the need for highly enriched uranium and high cost of uranium conversion processing to 93 percent ^{235}U at the cascades. Inventory frequency for enriched uranium below 20 percent ^{235}U was changed from monthly to bi-monthly effective 10-1-92.

4.2.3 Incidents

The 2 to 4 percent ^{235}U Hex to UO_2 program for B&W in Building 9211 resulted in an ID of approximately 400 kg during the period 1955 to 1959.

The below 20 percent ^{235}U Kukla program ID was approximately 125 kg. It was believed that since some of the parts were fabricated in the depleted uranium machining and foundry areas that the ID resulted from a mixture of Kukla turnings and oxide being disposed to the burial ground along with depleted discards.

4.3 Depleted Uranium

A historical review of the handling policies of depleted uranium (^{235}U below the naturally occurring level) was needed to put into perspective the current practices in accounting for this material. This depleted uranium is commonly referred to as D38. The D38 was in reference to the nominal assay of the depleted uranium which was usually .0038 percent ^{235}U.

To understand actions taken by the Y-12 Plant in handling D38, it is helpful to review the applicable history of normal and D38 processing within Y-12. The D38 has been considered a material of construction by both DOE and its predecessors and Y-12 personnel. Consequently, accurate accountability information has not been of paramount importance. Economic factors have been the controlling factors in D38 accountability.

No major technology changes were involved in the changeover. Due to the prior and then current value of normal uranium and the production control systems in place at the time of the changeover to D38, initial material accountability practices for D38 were the same as those used for normal material. However, it soon became apparent that considerable cost savings could be accomplished by the elimination of waybills (internal transfers) and changing from monthly to annual inventories. The AEC concurred with these changes in view of the lower value of D38 as well as its plentiful supply. The less demanding accountability practices were partially implemented in March 1954 and completed by July 1955. The first annual physical inventory of D38 was completed in June 1954 for the period March 1954 through June 1954. Annual inventories were taken during the last month of each fiscal year thereafter.

Processing of D38 continued using the practices employed for normal uranium until the second quarter of FY 1966 with some notable exceptions. The most notable was the discard of oxides generated in a burial ground west of the Y-12 Plant perimeter fence starting in FY 1954 and becoming significant in FY 1956.

The bulk of the D38 scrap generated at Y-12 was in the form of chips from the machining operations. For several years this material was processed using the technology developed for the recycle of normal uranium. This technology involved removal of extraneous material from the chips, pickling chips to remove excess oxide, washing to remove the pickling acid, chip crushing, and briquetting the crushed chips for casting charge material. Salvage generated by this process was discarded by burial of solids and discard of solutions to the S-3 ponds. Data on discards to the S-3 ponds is incomplete, since prior to FY 1972 such information was combined with burial ground data and separate records are not available.

Additional D38 scrap was generated by the many other processes used to produce D38 weapons components. This scrap was processed to reduce its bulk, when appropriate, and the solids buried while the liquids were dumped in the S-3 ponds.

New manufacturing processes as well as alloys of D38 were introduced through the fourth quarter of FY 1965, but the basic methods of recycling D38 chips and salvaging discards remained the same. One exception was the initiation of burial rather than briquetting D38-7 percent molybdenum chips in the third quarter of FY 1957. The apparent ID for D38 approximately doubled for this fiscal year. Briquette production varied between Accountability records show that discards to the burial ground started at 41 kg in FY 1954, increased to a maximum of 1,492,895 kg in FY 1961, and declined to 205,680 kg in FY 1963. The cumulative total to the end of FY 1963 was 2,746,267 kg. The amounts listed are from accountability records which, in reality, should not include as many significant figures as indicated.

During this time period, many discards were estimated. The factors used to estimate discards were changed from time to time based on then current information and presumably improved from time to time, but no back corrections were made. Amounts reported were listed to the nearest kg for bookkeeping purposes and to facilitate ID reporting. The significant figures reported for the estimates as well as the measurements in no way reflect the precision or accuracy of the va:. -s. In support of this statement, the values of material sent to the S-3 ponds as liqu:. :lvage were biased samples, not necessarily representative of the solutions, taken at -gular intervals and applied to large volumes of solution. Similarly, oxide from various operations was sampled a few times, a factor developed, and applied to continuing operations.

The conclusion that may be drawn is that the receipts and shipments were well known but that specific discard streams were not precisely identified. It is evident that an overall material balance may be made on the cumulative situation, but the specific individual discard streams may not be precisely quantified.

Starting in FY 1966, machine chips were no longer recycled but were discarded to the burial ground. The decision to stop recycle of these chips was made based on economics.

The discarding of D38 machine chips to the burial ground presented some problems with respect to accountability. Previous weights were available on briquettes sent back for recasting as well as samples of most of the discard streams from the chip recycle process were taken. These provided estimates of the material flow quantities in the chip recycle stream. When direct discard of the chips was initiated, such information was no longer available. The information that was available depended on the discard method used. The machine chips were collected in the machine shop and transferred to a dumpster which was filled with enough water to cover the chips to prevent the pyrophoric chips from burning.

An approximate tare weight of the dumpster and its transporting truck was obtained and subtracted from the gross weight of a truck with a loaded dumpster. A standard allowance was made for the weight of water. The resulting net weight was assumed to be the weight of chips in the dumpster. Major accountability problems with this system were as follows:

- the precision of the truck scales which were calibrated annually,
- variations in the weight of dumpsters,
- variation in truck weights due to fuel loading as well as cleanliness, and
- variations in water loading of the dumpsters.

The above problems were recognized by the NMC&A personnel and the operating groups.

In view of the low value of D38 and the minimal emphasis by the DOE and the plant for safeguarding D38 and the costs of making major improvements in the machine chip accountability system, no significant improvements were made in the system. Examination of the records with respect to discard weights to the burial grounds show variability of ±20 percent in the net weight contained in dumpster loads.

Until FY 1971, discards of D38 chips to the Y-12 burial ground were burned in the trenches used for burial. Experience indicated that uncontrolled burning would occur in the chips dumped in the trenches unless the chips were ignited and burned each day. This methodology resulted in high utilization of the trenches into which the chips were dumped. The volume occupied by the chips was reduced, and trench backfilling with dirt was required at infrequent intervals.

Records show that D38 discards to burial grounds prior to FY 1960 (FY 1953 through FY 1959) were sent to Oak Ridge National Laboratory (ORNL). The accountability values for this material show a cumulative total of 522,175 kg.

During 1969, corrosion resistant alloys of D38 were introduced in production at the Y-12 Plant. The first of these was called mulberry, and it was followed by a binary alloy. These alloys replaced pure D38 as the principle depleted material processed by Y-12. Since the alloys are corrosion resistant, machine chips of the alloys do not burn readily; therefore, the machine chips were merely dumped in trenches in the burial ground and then covered with fill dirt. Recycle of scrap alloy was evaluated including machine chips. It was found that only limited recycle was economically possible while maintaining the requisite material purity. This recycle was primarily limited to large pieces of scrap and did not include the majority of the machine chips for both economic and purity maintenance reasons.

Depleted uranium continued to be referred to as D38 even though through the years the value decreased to .0028 percent ^{235}U and then to .0020 percent ^{235}U as the diffusion plants became more efficient in extracting ^{235}U from feed material.

The accountability records indicating a negative ID present a somewhat distorted picture of the discards due to lack of good measurements. A better cumulative picture of the discards may be obtained using the following line of reasoning:

- Of the D38 received, all but that in the weapons stockpile and that at Y-12 in storage or in the production pipeline has been discarded either to the burial grounds or other discards. The bulk of the discards have been made to the burial ground. Other discards do not constitute a significant amount of material.

- The above reasoning may be quantified using the measured values for shipments and receipts as well as the ending physical inventory.

Using the above two values, discards may be calculated as totaling 19,112,142 kg. This may be compared to the cumulative NMC&A value of 19,989,516 kg (a difference of 877,374 kg or 4.4 percent).

From this, it may be concluded that the estimated discards have been overstated but only by a relatively small amount. This is not surprising since it is recognized that the discards were not well known, as discussed previously. The difference between the two values is about 4 percent of the lower number which is considered to be reasonable agreement in light of the described circumstances.

It is concluded that from the above discussions that D38 has been reasonably well accounted for in the Y-12 Plant. In view of the lack of value of D38, the perception that it was little more than a unique material of construction and that the economy of operation was a desirable goal, accountability practices have been historically appropriate. All data and information show that the bulk of the discards have been to the Y-12 burial grounds.

4.3.1 Data

The annual depleted uranium throughput is ·own in Table XVII for the period FY 1953 through FY 1994. Both element an: :tope values are shown for each year. Table XVIII shows annual totals for shiр...ents, NOLs, adjustments, EI, and ID with the exception of some missing data from the period CY 1947 through FY 1952. Table XIX lists total ID by year and cumulative CY 1947 through FY 1994. Tables XX through XXV give details for NOLs to the burial ground, sanitary and storm sewer, S-3 Pond, Y-12 holding area, transfers to K-25 holding area described as Toxic Substances Control Act (TSCA), and atmosphere.

Table XVI
Annual Enriched Uranium Below 20 Percent ^{235}U Discards to Atmosphere/Stacks
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
FY 1956[35]	-[36]	-	-	-
FY 1957	-	-	-	-
FY 1958	-	-	-	-
FY 1959	23[37]	1	23	1
FY 1960	-	-	23	1
FY 1961	-	-	23	1
FY 1962	-	-	23	1
FY 1963	-	-	23	1
FY 1964	-	-	23	1
FY 1965	-	-	23	1
FY 1966	-	-	23	1
FY 1967	-	-	23	1
FY 1968	-	-	23	1
FY 1969	-	-	23	1
FY 1970	-	-	23	1
FY 1971	-	-	23	1
FY 1972	-	-	23	1
FY 1973	-	-	23	1
FY 1974	-	-	23	1
FY 1975	-	-	23	1
FY 1976	-	-	23	1
FY 1976A (3 mo.)	-	-	23	1
FY 1977	-	-	23	1
FY 1978	-	-	23	1
FY 1979	-	-	23	1
FY 1980	-	-	23	1
FY 1981	-	-	23	1
FY 1982	-	-	23	1
FY 1983	-	-	23	1
FY 1984	-	-	23	1
FY 1985	-	-	23	1
FY 1986	-	-	23	1
FY 1987	-	-	23	1
FY 1988	-	-	23	1
FY 1989	-	-	23	1
FY 1990	-	-	23	1
FY 1991	-	-	23	1
FY 1992	-	-	23	1
FY 1993	-	-	23	1
FY 1994	-	-	23	1

35 Transactions for stacks were first reported in FY 1956.

36 Dash represents no transactions.

37 This amount was an inadvertent release of uranium hexafluoride to the atmosphere from processing 3 and 4 percent ^{235}U.

SECRET

Table XIX
Annual Summary of Depleted Uranium ID
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
CY 1947	21	0	21	0
CY 1948	3	0	24	0
CY 1949	-205	0	-181	0
CY 1950	-1	0	-182	0
CY 1951 (6 mo.)	0	0	-182	0
FY 1952	0	0	-182	0
FY 1953	0	0	-182	0
FY 1954	3,314	13	3,132	13
FY 1955	22,683	64	25,815	77
FY 1956	25,288	108	51,103	185
FY 1957	44,909	-545	96,012	-360
FY 1958	-982	-388	95,030	-748
FY 1959	27,201	-608	122,231	-1,356
FY 1960	-23,239	-1,935	98,992	-3,291
FY 1961	36	-986	99,028	-4,277
FY 1962	-94,335	-1,092	4,693	-5,369
FY 1963	121,540	246	126,233	-5,123
FY 1964	46,386	119	172,619	-5,004
FY 1965	10,986	40	183,605	-4,964
FY 1966	16	0	183,621	-4,964
FY 1967	65,530	614	249,151	-4,350
FY 1968	-23,445	-47	225,706	-4,397
FY 1969	-134,386	-258	91,320	-4,655
FY 1970	-1,745	-3	89,575	-4,658
FY 1971	-227,563	-455	-137,988	-5,113
FY 1972	-63,088	-312	-201,076	-5,425
FY 1973	75,218	130	-125,858	-5,295
FY 1974	-308,567	-641	-434,425	-5,936
FY 1975	75,970	215	-358,455	-5,721
FY 1976	98,159	391	-260,296	-5,330
FY 1976A (3 mo.)	-3,776	-7	-264,072	-5,337
FY 1977	-339,696	-459	-603,768	-5,796
FY 1978	239,449	580	-364,319	-5,216
FY 1979	-451,939	-810	-816,258	-6,026
FY 1980	-471,510	-839	-1,287,768	-6,865
FY 1981	85,340	112	-1,202,428	-6,753
FY 1982	297,524	398	-904,904	-6,355
FY 1983	-162,840	-189	-1,067,744	-6,544
FY 1984	-431,411	-531	-1,499,155	-7,075
FY 1985	-271,320	-6,926	-1,770,475	-14,001
FY 1986	-113,369	6,412	-1,883,844	-7,589
FY 1987	-199,806	-481	-2,083,650	-8,070
FY 1988	81,803	36	-2,001,847	-8,034
FY 1989	-16,174	-251	-2,018,021	-8,285
FY 1990	-10,922	-341	-2,028,943	-8,626
FY 1991	-256,461	-414	-2,285,404	-9,040
FY 1992	320,213	624	-1,965,191	-8,416
FY 1993	-161,006	-279	-2,126,197	-8,695
FY 1994	792	120	-2,125,405	-8,575

Minus denotes gain.

SECRET

Table XX

Annual Depleted Uranium Discards to Burial Ground

(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
CY 1947	-[42]	-	-	-
CY 1948	-	-	-	-
CY 1949	-	-	-	-
CY 1950	-	-	-	-
CY 1951 (6 mo.)	-	-	-	-
FY 1952	-	-	-	-
FY 1953[43]	0[44]	0	0	-
FY 1954[45]	41	1	41	0
FY 1955[45]	281	1	322	1
FY 1956[45]	24,253	68	24,575	2
FY 1957[45]	103,859	297	128,434	70
FY 1958[45]	148,731	413	277,165	367
FY 1959[45]	245,010	701	522,175	780
				1,481
FY 1960	231,586	648	753,761	2,129
FY 1961	1,492,895	4,174	2,246,656	6,303
FY 1962	293,931	824	2,540,587	7,127
FY 1963	205,680	576	2,746,267	7,703
FY 1964	637,087	1,784	3,383,354	9,487
FY 1965	373,849	1,047	3,757,203	10,534
FY 1966	1,303,314	3,649	5,060,517	14,183
FY 1967	928,441	2,460	5,988,958	16,643
FY 1968	277,815	553	6,266,773	17,196
FY 1969	528,242	1,053	6,795,015	18,249
FY 1970	656,601	1,315	7,451,616	19,564
FY 1971	787,527	1,576	8,239,143	21,140
FY 1972	1,059,474	2,117	9,298,617	23,257
FY 1973	684,801	1,367	9,983,418	24,624
FY 1974	918,577	1,839	10,901,995	26,463
FY 1975	463,807	922	11,365,802	27,385
FY 1976	311,373	617	11,677,175	28,002
FY 1976A (3 mo.)	49,716	96	11,726,891	28,098
FY 1977	293,046	584	12,019,937	28,682
FY 1978	601,724	1,192	12,621,661	29,874
FY 1979	461,950	921	13,[illegible],611	30,795
FY 1980	999,343	1,987	[illegible]4 [illegible].954	32,782
FY 1981	618,216	1,321	14,[illegible],170	34,103
FY 1982	871,466	1,772	15,572,636	35,875
FY 1983	971,245	1,865	16,543,881	37,740
FY 1984	1,376,519	2,619	17,920,400	40,359
FY 1985	1,001,321	1,868	18,921,721	42,227
FY 1986	565,383	1,039	19,487,104	43,266
FY 1987	383,345	689	19,870,449	43,955
FY 1988	74,690	127	19,945,139	44,082
FY 1989	32,066	55	19,977,205	44,137
FY 1990	12,259	31	19,989,464	44,168
FY 1991	51	0	19,989,515	44,168
FY 1992	0	0	19,989,515	44,168
FY 1993	0	0	19,989,515	44,168
FY 1994	1[45]	0	19,989,516	44,168

[42] Dash represents no transactions.

[43] Prior to FY 1953, depleted U discards were combined with below 20 percent ^{235}U discards.

[44] Zero represents transactions less than 500 grams.

[45] Disposed to X-10 Burial Ground.

Table XXI
Annual Depleted Uranium Discards to Sanitary/Storm Sewer
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
CY 1947	-[46]	-	-	-
CY 1948	-	-	-	-
CY 1949	-	-	-	-
CY 1950	-	-	-	-
CY 1951 (6 mo.)	-	-	-	-
FY 1952	-	-	-	-
FY 1953[47]	-	-	-	-
FY 1954	10	0	10	0
FY 1955	41	0	51	0
FY 1956	557	2	608	2
FY 1957	1,094	3	1,702	5
FY 1958	504	2	2,206	7
FY 1959	787	2	2,993	9
FY 1960	584	2	3,577	11
FY 1961	225	1	3,802	12
FY 1962	36	0	3,838	12
FY 1963	10	0	3,848	12
FY 1964	17	0	3,865	12
FY 1965	8	0	3,873	12
FY 1966	32	0	3,905	12
FY 1967	21	0	3,926	12
FY 1968	17	0	3,943	12
FY 1969	26	0	3,969	12
FY 1970	30	0	3,999	12
FY 1971	15	0	4,014	12
FY 1972	1,627	3	5,641	15
FY 1973	1,796	3	7,437	18
FY 1974	1,600	0	9,037	18
FY 1975	1,427	1	10,464	19
FY 1976	623	0	11,087	19
FY 1976A (3 mo.)	66	0	11,153	19
FY 1977	602	0	11,755	19
FY 1978	442	0	12,197	19
FY 1979	356	0	12,553	19
FY 1980	232	0	12,785	19
FY 1981	347	0	13,132	19
FY 1982	253	0	13,385	19
FY 1983	560	0	13,945	19
FY 1984	501	0	14,446	19
FY 1985	909	1	15,355	20
FY 1986	298	0	15,653	20
FY 1987	380	0	16,033	20
FY 1988	254	0	16,287	20
FY 1989	325	0	16,612	20
FY 1990	227	0	16,839	20
FY 1991	310	0	17,149	20
FY 1992	192	0	17,341	20
FY 1993	152	0	17,493	20
FY 1994	252	0	17,745	20

46 Dash represents no transactions.

47 Prior to FY 1953, depleted uranium discards were combined with below 20 percent ^{235}U discards.

Table XXII
Annual Depleted Uranium Discards to S-3 Pond
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
FY 1972[48]	2,228	4	2,228	4
FY 1973	763	1	2,991	5
FY 1974	3,799	7	6,790	12
FY 1975	1,319	2	8,109	14
FY 1976	799	2	8,908	16
FY 1976A (3 mo.)	2	0	8,910	16
FY 1977	1,698	4	10,608	20
FY 1978	1,566	3	12,174	23
FY 1979	1,407	3	13,581	26
FY 1980	730	2	14,311	28
FY 1981	79	0	14,390	28
FY 1982	795	1	15,185	29
FY 1983	409	1	15,594	30
FY 1984	0[49]	0	15,594	30
FY 1985[50]	-	-	15,594	30
FY 1986	-	-	15,594	30
FY 1987	-	-	15,594	30
FY 1988	-	-	15,594	30
FY 1989	-	-	15,594	30
FY 1990	-	-	15,594	30
FY 1991	-	-	15,594	30
FY 1992	-	-	15,594	30
FY 1993	-	-	15,594	30
FY 1994	-	-	15,594	30

48 Prior to FY 1972, S-3 Pond values were combined with burial ground totals.

49 Zero represents transactions less than 500 grams.

50 The S-3 Pond at Y-12 was officially closed September 30, 1984.

Table XXIII
Annual Depleted Uranium Discards to Y-12 Holding Area (FZBH, FZFH)
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
FY 1984				
FY 1985				
FY 1986				
FY 1987				
FY 1988				
FY 1989				
FY 1990				
FY 1991				
FY 1992				
FY 1993				
FY 1994				

Table XXIV
Annual Depleted Uranium Discards to K-25 TSCA Holding Area (FZEI)
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
FY 1984	-	-	-	-
FY 1985	-	-	-	-
FY 1986	-	-	-	-
FY 1987	1,722	4	1,722	4
FY 1988	109,999	219	111,721	223
FY 1989	187,187	372	298,908	595
FY 1992	225	36	299,133	631
FY 1993	303	16	299,436	647
FY 1992	3,495	1	302,931	648
FY 1993	287	(1)	303,218	647
FY 1994	116	0	303,334	647

Table XXV

Annual Depleted Uranium Discards to Atmosphere/Stacks (FZFA)

(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
FY 1984	-	-	-	-
FY 1985	-	-	-	-
FY 1986	-	-	-	-
FY 1987	15	0	15	0
FY 1988	18	0	33	0
FY 1989	6	0	39	0
FY 1990	5	0	44	0
FY 1991	1	0	45	0
FY 1992	0	0	45	0
FY 1993	0	0	45	0
FY 1994	0	0	45	0

4.3.2 Trends and Interpretations

Significant quantities of depleted uranium (D38) metal started to be received in Y-12 from National Lead of Ohio (NLO) in FY 1953.

During the period 1953—1959, as long as the isotopic assay of depleted crucible oxide was higher than current tails assay at K-25, Y-12 shipped crucible oxide to K-25 to be reprocessed to feed for the diffusion plant.

In January 1954, D38 replaced normal uranium in Sunflower (depleted uranium) fabrication. Until then, there was a mix of normal and depleted in the fabrication stream.

In March 1954, physical inventories for D38 were changed from monthly to annually (end of fiscal year).

The first Request for Approved Inventory Write-offs (AIWO) is dated August 20, 1959. The form was initially designed to record nonroutine "write-offs" only; however, in June 1960, the form was changed to include routine monthly discards for a fiscal year. These requests were approved in advance by the AEC, ORO. Prior to August 1959, all requests to remove accountable material from inventory were handled on an individual request basis by letter to AEC.

4.3.3 Incidents

Known incidents are covered under sections 4.3, Depleted Uranium, and 4.3.2, Trends and Interpretations.

4.4 Normal Uranium

The Y-12 Plant started processing (i.e., machining) normal uranium for nuclear weapons components about November 1947. A special machine shop was set up in Building 9766 to machine castings received from Mallinckrodt. At this time, plans were made to produce shaped castings in Y-12 in Building 9212 as well as to move the machining operations from Building 9766 to Building 9212.

Accountability practices consisted of weighing the received castings, the machined casting, and generated chips and attributing the difference to salvage. The salvage was analyzed and a material balance obtained. Some salvage was discarded to burial grounds. Specific values for such discards are not available as normal discards were combined with below 20 percent ^{235}U discards prior to FY 1953. Discards prior to FY 1960 were sent to the ORNL burial grounds. At about this time, machine chips from other AEC locations were being sent to Y-12. Initially, such shipments were placed on the Y-12 books at the shipper's weight. Subsequent efforts at Y-12 indicated that significant discrepancies existed between shipper's weights and Y-12 measured values, but no back corrections were possible since the early shipments had been processed.

The Y-12 Plant reprocessed machine chips (both those generated by Y-12 and those received from other AEC installations) by washing, crushing, and briquetting, followed by recasting. These activities were initiated during CY 1948. Experiments conducted during this period resulted in a chip washing process followed by crushing prior to briquetting.

The process developed provided an improved estimate of the uranium contained in the machine chips. Recent experience, however, has shown that no good method has yet been developed to provide a precise value for the uranium contained in machine chips as they are received.

Production, recycle, discards, and accountability processes remained basically as described above.

In addition to machining normal uranium for weapons components, the Y-12 Plant machined normal uranium slugs for the ORNL, Hanford, and Savannah River Operations (SRO) reactors in FY 1953. The program supplying slugs to ORNL continued in FY 1954. Scrap processing and accountability practices were as described above.

One specific scrap stream has not been described. When Y-12 started casting normal uranium in 1948, quantities of oxide (crucible oxide) were generated. These were sent to K-25 for use as feed in the gaseous diffusion process.

The machining of slugs for ORNL in FY 1954 as well as the manufacture of special components for others has continued but has not involved significant quantities of material except for shipments of rods to SRO, chips to NLO, and crucible oxide to K-25 in FY 1960.

Discards of normal uranium to burial grounds totaled 22,539 kg uranium from CY 1947 through FY 1984. As previously stated, discards of normal uranium prior to FY 1953 were combined with below 20 percent ^{235}U discards. No information is available to separate these discards by assay. Such discards total 170 kg uranium, which is not considered to be a significant quantity. Discards to a burial ground were sent to ORNL through FY 1959. These discards totaled 1,525 kg uranium.

Normal uranium discards to the sanitary and storm sewers have been estimated as a total of 3,111 kg uranium for FY 1953 through FY 1976. Prior to FY 1953, normal plus below 20 percent ^{235}U sewer discards have been estimated at a total of 55 kg uranium.

Several loss streams, now estimated, were not considered during these early years. Examples of such streams are stack losses and trackout. Although storm and sanitary sewer losses were estimated, such estimates during this period were at best only rough estimates.

4.4.1 Data

The DOE reporting requirement for normal uranium is for element values only. The annual normal uranium throughput is shown in Table XXVI for the period CY 1947 through FY 1994. This table shows annual totals for receipts, throughput, and adjustments. Table XXVII shows annual totals for shipments, NOLs, adjustments, EI, and ID for the period CY 1947 through FY 1994. Table XXVIII lists ID by year and cumulative to date CY 1947 through FY 1994. Tables XXIX through XXXI give annual totals for discards to the burial ground, sanitary and storm sewer, and S-3 Pond.

Table XXVIII
Annual Summary of Normal Uranium ID
(kg)

Period	U	^{235}U	Cumulative U	Cumulative ^{235}U
CY 1947	- 411		- 411	
FY 1948	286		- 125	
CY 1949	361		236	
CY 1950	400		636	
CY 1951 (6 mo.)	777		1,413	
FY 1952	1,402		2,815	
FY 1953	355		3,170	
FY 1954	46		3,216	
FY 1955	17		3,233	
FY 1956	485		3,718	
FY 1957	474		4,192	
FY 1958	- 128		4,064	
FY 1959	- 21		4,043	
FY 1960	31		4,074	
FY 1961	8		4,082	
FY 1962	16		4,098	
FY 1963	1		4,099	
FY 1964	- 1		4,098	
FY 1965	- 6		4,092	
FY 1966	1,533		5,625	
FY 1967	1,266		6,891	
FY 1968	962		7,853	
FY 1969	409		8,262	
FY 1970	- 9		8,253	
FY 1971	65		8,318	
FY 1972	- 417		7,901	
FY 1973	368		8,269	
FY 1974	134		8,403	
FY 1975	- 73		8,330	
FY 1976	- 1		8,329	
FY 1976A (3 mo.)	- 68		8,261	
FY 1977	1		8,262	
FY 1978	- 231		8,031	
FY 1979	- 214		7,817	
FY 1980	140		7,957	
FY 1981	146		8,103	
FY 1982	55		8,158	
FY 1983	- 72		8,086	
FY 1984	- 184		7,902	
FY 1985	- 66		7,836	
FY 1986	- 43		7,793	
FY 1987	-11,127		- 3,334	
FY 1988	11,197		7,863	
FY 1989	- 2		7,861	
FY 1990	-		7,861	
FY 1991	- 259		7,602	
FY 1992	- 570		7,032	
FY 1993	620		7,652	
FY 1994	41		7,693	

Minus denotes gain.

Table XXIX
Annual Normal Uranium Discards to Burial Ground
(kg)

Period	U	Cumulative U
CY 1947	-[56]	-
CY 1948	-	-
CY 1949	-	-
CY 1950	-	-
CY 1951 (6 mo.)	-	-
FY 1952	-	-
FY 1953[57, 58, 59]	170	170
FY 1954[59]	251	421
FY 1955[59]	41	462
FY 1956[59]	308	770
FY 1957[59]	148	918
FY 1958[59]	39	957
FY 1959[59]	568	1,525
FY 1960	2,480	4,005
FY 1961	1,465	5,470
FY 1962	1,253	6,723
FY 1963	10	6,733
FY 1964	31	6,764
FY 1965	77	6,841
FY 1966	301	7,142
FY 1967	110	7,252
FY 1968	128	7,380
FY 1969	158	7,538
FY 1970	0[60]	7,538
FY 1971	22	7,560
FY 1972	1,592	9,152
FY 1973	51	9,203
FY 1974	609	9,812
FY 1975	34	9,846
FY 1976	1,892	11,738
FY 1976A (3 mo.)	15	11,753
FY 1977	9,486	21,239
FY 1978	258	21,497
FY 1979	537	22,034

[56] Dash represents no transactions.

[57] Prior to FY 1953, normal U discards were combined with below 20 percent ^{235}U discards.

[58] Includes 161 kg disposed to X-10 Burial Ground.

[59] Disposed to X-10 Burial Ground.

[60] Zero represents transactions less than 500 grams.

Table XXIX (continued)
Annual Normal Uranium Discards to Burial Ground
(kg)

Period	U	Cumulative U
FY 1980	8	22,042
FY 1981	90	22,132
FY 1982	204	22,336
FY 1983	178	22,514
FY 1984	25	22,539
FY 1985	416	22,955
FY 1986	7,384	30,339
FY 1987	51	30,390
FY 1988	189	30,579
FY 1989	0	30,579
FY 1990	0	30,579
FY 1991	0	30,579
FY 1992	0	30,579
FY 1993	-	30,579
FY 1994	-	30,579

Table XXX

Annual Normal Uranium Discards to Sanitary/Storm Sewer

(kg)

Period	U	Cumulative U
CY 1947	-[61]	-
CY 1948	-	-
CY 1949	-	-
CY 1950	-	-
CY 1951 (6 mo.)	-	-
FY 1952	-	-
FY 1953[62]	13	13
FY 1954	59	72
FY 1955	129	201
FY 1956	1,613	1,814
FY 1957	11	1,825
FY 1958	11	1,836
FY 1959	1,171	3,007
FY 1960	21	3,028
FY 1961	26	3,054
FY 1962	27	3,081
FY 1963	5	3,086
FY 1964	3	3,089
FY 1965	14	3,103
FY 1966	5	3,108
FY 1967	3	3,111
FY 1968	-	3,111
FY 1969	-	3,111
FY 1970	-	3,111
FY 1971	-	3,111
FY 1972	-	3,111
FY 1973	-	3,111
FY 1974	0[63]	3,111
FY 1975	-	3,111
FY 1976	-	3,111
FY 1976A (3 mo.)	-	3,111
FY 1977	-	3,111
FY 1978	-	3,111
FY 1979	-	3,111
FY 1980	-	3,111
FY 1981	-	3,111
FY 1982	-	3,111
FY 1983	-	3,111
FY 1984	-	3,111
FY 1985	-	3,111
FY 1986	-	3,111
FY 1987	-	3,111
FY 1988	-	3,111
FY 1989	-	3,111
FY 1990	-	3,111
FY 1991	-	3,111
FY 1992	-	3,111
FY 1993	-	3,111
FY 1994	-	3,111

61 Dash represents no transactions.

62 Prior to FY 1953, normal U discards were combined with below 20 percent ^{235}U discards.

63 Zero represents transactions less than 500 grams.

Table XXXI
Annual Normal Uranium Discards to S-3 Pond
(kg)

Period	U	Cumulative U
FY 1972[64]	1	1
FY 1973	0[65]	1
FY 1974	0	1
FY 1975	0	1
FY 1976	0	1
FY 1976A (3 mo.)	0	1
FY 1977	0	1
FY 1978	1	2
FY 1979	0	2
FY 1980	0	2
FY 1981	-[66]	2
FY 1982	0	2
FY 1983	-	2
FY 1984	-	2
FY 1985[67]	-	2
FY 1986	-	2
FY 1987	-	2
FY 1988	-	2
FY 1989	-	2
FY 1990	-	2
FY 1991	-	2
FY 1992	-	2
FY 1993	-	2
FY 1994	-	2

64 Prior to FY 1972, S-3 Pond values were combined with burial ground totals.

65 Zero represents transactions less than 500 grams.

66 Dash represents no transactions.

67 The S-3 Pond at Y-12 was officially closed September 30, 1984.

4.4.2 Trends and Interpretations

This section is covered under 4.4, Normal Uranium.

4.4.3 Incidents

This section is included in 4.4, Normal Uranium.

4.5 Thorium

The first record of thorium used in Y-12 was the January 1, 1947, inventory At that time, the inventory was used in research and development studies primarily by ORNL personnel in the Y-12 Plant. It was not until FY 1952 that thorium activity increased significantly. The thorium material balance for FY 1952 was 83 kg BI; receipts; shipped; 263 kg EI, with an ID of The shipments and receipts were primarily between Y-12 and ORNL.

During the period 1952-1958, ORNL carried on experimental work with thorium at the Y-12 Plant. The ORNL Reactor Experimental Engineering Organization was developing thorium systems to be used in aqueous homogeneous reactors.

Feed materials for the weapons program were received from W. R. Grace & Co. (MDC & DCC), Nuclear Fuel Services (FXA), Teledyne Wah Chang (FDW), and ORNL (ORL). RISs are associated with each supplier of feed identified above.

4.5.1 Data

The annual thorium throughput is shown in Table XXXII for the period CY 1947 through FY 1994. Table XXXIII shows annual totals for shipments, NOLs, adjustments, EI, and ID for the same period as throughput. Table XXXIV lists ID by year and cumulative for the period CY 1947 through FY 1994. Table XXXV through Table XXXVII show discards to the burial ground, sanitary and storm sewer, and S-3 Pond.

Table XXXV
Annual Thorium Discards to Burial Ground
(kg)

Period	Th	Cumulative Th
CY 1947[72]	1	1
CY 1948	-[73]	1
CY 1949	-	1
CY 1950	-	1
CY 1951 (6 mo.)	-	1
FY 1952[72]	0[74]	1
FY 1953[72]	0	1
FY 1954[72]	0	1
FY 1955[72]	0	8
FY 1956[72]	12	20
FY 1957[72]	652	672
FY 1958[72]	252	924
FY 1959[72,75]	694	1,618
FY 1960	0	1,618
FY 1961	807	2,425
FY 1962	2,514	4,939
FY 1963	3,167	8,106
FY 1964	14,447	22,553
FY 1965	15,098	37,651
FY 1966	6,586	44,237
FY 1967	5,914	50,151
FY 1968	517	50,668
FY 1969	770	51,438
FY 1970	10,052	61,490
FY 1971	8,628	70,118
FY 1972	10,083	80,201
FY 1973	7,573	87,774
FY 1974	8,131	95,905
FY 1975	9,362	105,267
FY 1976[76]	736	106,003
FY 1976A (3 mo.)	0	106,003
FY 1977[77]	0	106,003
FY 1978	0	106,003
FY 1979	0	106,003

72 Disposed to X-10 Burial Ground.

73 Dash represents no transactions.

74 Zero represents transactions less than 500 grams.

75 FY 1959 Included 444 kg from MBA 81, ORNL Reactor Technical Division

76 FY 1976 does not include disposed to retrievable burial ground.

77 In FY 1977, 267 kg (calculated value) of Th was transferred to Y-12 burial ground from Nuclear Chemicals and Metals Corporation (FCY), Huntsville, TN, for the state of Tennessee. This value is not included in this table.

Table XXXV (continued)
Annual Thorium Discards to Burial Ground
(kg)

Period	Th	Cumulative Th
FY 1980	340	106,343
FY 1981	252	106,595
FY 1982	0	106,595
FY 1983	64,397	170,992
FY 1984	85	171,077
FY 1985	0	171,077
FY 1986	0	171,077
FY 1987	1,824	172,901
FY 1988	36	172,937
FY 1989	0	172,937
FY 1990	-	172,937
FY 1991	-	172,937
FY 1992	-	172,937
FY 1993	-	172,937
FY 1994	-	172,937

Table XXXVI
Annual Thorium Discards to Sanitary/Storm Sewer
(kg)

Period	Th	Cumulative Th
CY 1947	-[78]	-
CY 1948	-	-
CY 1949	-	-
CY 1950	-	-
CY 1951 (6 mo.)	-	-
FY 1952	-	-
FY 1953	-	-
FY 1954	11	11
FY 1955	26	37
FY 1956	44	81
FY 1957	49	130
FY 1958	70	200
FY 1959	3,363	3,563
FY 1960	283	3,846
FY 1961	927	4,773
FY 1962	0[79]	4,773
FY 1963	20	4,793
FY 1964	7	4,800
FY 1965	-	4,800
FY 1966	-	4,800
FY 1967	-	4,800
FY 1968	-	4,800
FY 1969	-	4,800
FY 1970	-	4,800
FY 1971	-	4,800
FY 1972	-	4,800
FY 1973	-	4,800
FY 1974	65	4,865
FY 1975	195	5,060
FY 1976	175	5,235
FY 1976A (3 mo.)	28	5,263
FY 1977	176	5,439
FY 1978	120	5,559
FY 1979	93	5,652
FY 1980	80	5,732
FY 1981	85	5,817
FY 1982	52	5,869
FY 1983	49	5,918
FY 1984	90	6,008
FY 1985	153	6,161
FY 1986	64	6,225
FY 1987	27	6,252
FY 1988	4	6,256
FY 1989	0	6,256
FY 1990	-	6,256
FY 1991	-	6,256
FY 1992	-	6,256
FY 1993	-	6,256
FY 1994	-	6,256

[78] Dash represents no transactions.

[79] Zero represents transactions less than 500 grams.

Table XXXVII
Annual Thorium Discards to S-3 Pond
(kg)

Period	Th	Cumulative Th
FY 1972[80]	-[81]	-
FY 1973	-	-
FY 1974	629	629
FY 1975	592	1,221
FY 1976	-	1,221
FY 1976A (3 mo.)	-	1,221
FY 1977	-	1,221
FY 1978	-	1,221
FY 1979	-	1,221
FY 1980	-	1,221
FY 1981	-	1,221
FY 1982	-	1,221
FY 1983	-	1,221
FY 1984[82]	-	1,221
FY 1985	-	1,221
FY 1986	-	1,221
FY 1987	-	1,221
FY 1988	-	1,221
FY 1989	-	1,221
FY 1990	-	1,221
FY 1991	-	1,221
FY 1992	-	1,221
FY 1993	-	1,221
FY 1994	-	1,221

80 Prior to FY 1972 S-3 Pond values were combined with burial ground totals.

81 Dash represents no transactions.

82 The S-3 Pond at Y-12 was officially closed September 30, 1984.

Table LIV

Annual Summary of Plutonium (^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{242}Pu) ID

(gram)

Period	Pu	Cumulative Pu
CY 1949		
CY 1950		
CY 1951 (6 mo.)		
FY 1952		
FY 1953		
FY 1954		
FY 1955		
FY 1956		
FY 1957		
FY 1958		
FY 1959		
FY 1960		
FY 1961		
FY 1962		
FY 1963		
FY 1964		
FY 1965		
FY 1966		
FY 1967		
FY 1968		
FY 1969		
FY 1970		
FY 1971		
FY 1972		
FY 1973		
FY 1974		
FY 1975		
FY 1976		
FY 1976A (3 mo.)		
FY 1977		
FY 1978		
FY 1979		
FY 1980		
FY 1981		
FY 1982		
FY 1983		
FY 1984		
FY 1985		
FY 1986		
FY 1987		
FY 1988		
FY 1989		
FY 1990		
FY 1991		
FY 1992		
FY 1993		
FY 1994		

Minus denotes gain.

Table LV
Annual Plutonium (^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{242}Pu) NOLs
(gram)

Period	Pu	Cumulative Pu
CY 1949	0	0
CY 1950	-	0
CY 1951 (6 mo.)	-	0
FY 1952	-	0
FY 1953	0	0
FY 1954	3	3
FY 1955	0	3
FY 1956	10	13
FY 1957	0	13
FY 1958	85	98
FY 1959	87	185
FY 1960	99	284
FY 1961	127	411
FY 1962	0	411
FY 1963	-	411
FY 1964	-	411
FY 1965	-	411
FY 1966	-	411
FY 1967	-	411
FY 1968	-	411
FY 1969	-	411
FY 1970	-	411
FY 1971	-	411
FY 1972	-	411
FY 1973	-	411
FY 1974	-	411
FY 1975	-	411
FY 1976	-	411
FY 1976A (3 mo.)	-	411
FY 1977	-	411
FY 1978	-	411
FY 1979	-	411
FY 1980	-	411
FY 1981	-	411
FY 1982	-	411
FY 1983	-	411
FY 1984	-	411
FY 1985	-	411
FY 1986	-	411
FY 1987	-	411
FY 1988	-	411
FY 1989	-	411
FY 1990	-	411
FY 1991	-	411
FY 1992	-	411
FY 1993	-	411
FY 1994	-	411

Table LVI
Annual Plutonium (^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{242}Pu Discards to Burial Ground
(gram)

Period	Pu	Cumulative Pu
CY 1949	0[89]	0
CY 1950	-[90]	0
CY 1951 (6 mo.)	-	0
FY 1952	-	0
FY 1953[91]	0	0
FY 1954[91]	3	3
FY 1955[91]	0	3
FY 1956[91]	10	13
FY 1957[91]	0	13
FY 1958[91]	85	98
FY 1959[91]	87	185
FY 1960[91]	99	284
FY 1961[91]	127	411
FY 1962[91]	0	411
FY 1963	-	411
FY 1964	-	411
FY 1965	-	411
FY 1966	-	411
FY 1967	-	411
FY 1968	-	411
FY 1969	-	411
FY 1970	-	411
FY 1971	-	411
FY 1972	-	411
FY 1973	-	411
FY 1974	-	411
FY 1975	-	411
FY 1976	-	411
FY 1976A (3 mo.)	-	411
FY 1977	-	411
FY 1978	-	411
FY 1979	-	411
FY 1980	-	411
FY 1981	-	411
FY 1982	-	411
FY 1983	-	411
FY 1984	-	411
FY 1985	-	411
FY 1986	-	411
FY 1987	-	411
FY 1988	-	411
FY 1989	-	411
FY 1990	-	411
FY 1991	-	411
FY 1992	-	411
FY 1993	-	411
FY 1994	-	411

[89] Zero represents transactions less than .5 gram.

[90] Dash represents no transactions.

[91] Disposed to X-10 burial ground.

Table LVII
Annual Plutonium (^{238}Pu, ^{239}Pu, ^{240}Pu, and ^{242}Pu) Discards to Sanitary/Storm Sewer
(gram)

Period	Pu	Cumulative Pu
CY 1949	-[92]	-
CY 1950	-	-
CY 1951 (6 mo.)	-	-
FY 1952	-	-
FY 1953	-	-
FY 1954	-	-
FY 1955	0[93]	0
FY 1956	0	0
FY 1957	-	0
FY 1958	-	0
FY 1959	-	0
FY 1960	-	0
FY 1961	-	0
FY 1962	-	0
FY 1963	-	0
FY 1964	-	0
FY 1965	-	0
FY 1966	-	0
FY 1967	-	0
FY 1968	-	0
FY 1969	-	0
FY 1970	-	0
FY 1971	-	0
FY 1972	-	0
FY 1973	-	0
FY 1974	-	0
FY 1975	-	0
FY 1976	-	0
FY 1976A (3 mo.)	-	0
FY 1977	-	0
FY 1978	-	0
FY 1979	-	0
FY 1980	-	0
FY 1981	-	0
FY 1982	-	0
FY 1983	-	0
FY 1984	-	0
FY 1985	-	0
FY 1986	-	0
FY 1987	-	0
FY 1988	-	0
FY 1989	-	0
FY 1990	-	0
FY 1991	-	0
FY 1992	-	0
FY 1993	-	0
FY 1994	-	0

[92]Dash represents no transactions.

[93]Zero represents transaction less than .5 gram.

Table LX
Annual Summary of Uranium ^{233}U ID
(gram)

Period	U	^{233}U	Cumulative U	Cumulative ^{233}U
CY 1947				
CY 1948				
CY 1949				
CY 1950				
CY 1951 (6 mo.)				
FY 1952				
FY 1953				
FY 1954				
FY 1955				
FY 1956				
FY 1957				
FY 1958				
FY 1959				
FY 1960				
FY 1961				
FY 1962				
FY 1963				
FY 1964				
FY 1965				
FY 1966				
FY 1967				
FY 1968				
FY 1969				
FY 1970				
FY 1971				
FY 1972				
FY 1973				
FY 1974				
FY 1975				
FY 1976				
FY 1976A (3 mo.)				
FY 1977				
FY 1978				
FY 1979				
FY 1980				
FY 1981				
FY 1982				
FY 1983				
FY 1984				
FY 1985				
FY 1986				
FY 1987				
FY 1988				
FY 1989				
FY 1990				
FY 1991				
FY 1992				
FY 1993				
FY 1994				

Minus denotes gain.

Table LXI
Annual Uranium ^{233}U NOLs
(gram)

Period	U	^{233}U	Cumulative U	Cumulative ^{233}U
CY 1947	-	-	-	-
CY 1948	-	-	-	-
CY 1949	-	-	-	-
CY 1950	-	-	-	-
CY 1951 (6 mo.)	-	-	-	-
FY 1952	-	-	-	-
FY 1953	2	2	2	2
FY 1954	1	1	3	3
FY 1955	-	-	3	3
FY 1956	5	3	8	6
FY 1957	5	3	13	9
FY 1958	-	-	13	9
FY 1959	35	31	48	40
FY 1960	19	19	67	59
FY 1961	20	20	87	79
FY 1962	-	-	87	79
FY 1963	62	60	149	139
FY 1964	17	6	166	145
FY 1965	-	-	166	145
FY 1966	-	-	166	145
FY 1967	304	290	470	435
FY 1968	415	380	885	815
FY 1969	1	1	886	816
FY 1970	26	26	912	842
FY 1971	-	-	912	842
FY 1972	-	-	912	842
FY 1973	-	-	912	842
FY 1974	-	-	912	842
FY 1975	-	-	912	842
FY 1976	-	-	912	842
FY 1976A (3 mo.)	-	-	912	842
FY 1977	-	-	912	842
FY 1978	-	-	912	842
FY 1979	-	-	912	842
FY 1980	-	-	912	842
FY 1981	-	-	912	842
FY 1982	-	-	912	842
FY 1983	-	-	912	842
FY 1984	-	-	912	842
FY 1985	-	-	912	842
FY 1986	-	-	912	842
FY 1987	-	-	912	842
FY 1988	-	-	912	842
FY 1989	-	-	912	842
FY 1990	-	-	912	842
FY 1991	-	-	912	842
FY 1992	-	-	912	842
FY 1993	-	-	912	842
FY 1994	-	-	912	842

Table LXII
Annual Uranium ^{233}U Discards to Burial Ground
(gram)

Period	U	^{233}U	Cumulative U	Cumulative ^{233}U
CY 1947	-[94]	-	-	-
CY 1948	-	-	-	-
CY 1949	-	-	-	-
CY 1950	-	-	-	-
CY 1951 (6 mo.)	-	-	-	-
FY 1952	-	-	-	-
FY 1953[95]	2	2	2	2
FY 1954[95]	1	1	3	3
FY 1955	-	-	3	3
FY 1956[95]	5	3	8	6
FY 1957[95]	5	3	13	9
FY 1958	-	-	13	9
FY 1959[95]	35	31	48	40
FY 1960[95]	19	19	67	59
FY 1961[95]	18	18	85	77
FY 1962	-	-	85	77
FY 1963[95]	62	60	147	137
FY 1964[95]	17	6	164	143
FY 1965	-	-	164	143
FY 1966	-	-	164	143
FY 1967	304	290	468	433
FY 1968	415	380	883	813
FY 1969	1	1	884	814
FY 1970	26	26	910	840
FY 1971	-	-	910	840
FY 1972	-	-	910	840
FY 1973	-	-	910	840
FY 1974	-	-	910	840
FY 1975	-	-	910	840
FY 1976	-	-	910	840
FY 1976A (3 mo.)	-	-	910	840
FY 1977	-	-	910	840
FY 1978	-	-	910	840
FY 1979	-	-	910	840
FY 1980	-	-	910	840
FY 1981	-	-	910	840
FY 1982	-	-	910	840
FY 1983	-	-	910	840
FY 1984	-	-	910	840
FY 1985	-	-	910	840
FY 1986	-	-	910	840
FY 1987	-	-	910	840
FY 1988	-	-	910	840
FY 1989	-	-	910	840
FY 1990	-	-	910	840
FY 1991	-	-	910	840
FY 1992	-	-	910	840
FY 1993	-	-	910	840
FY 1994	-	-	910	840

[94] Dash represents no transactions.

[95] Disposed to X-10 Burial Ground.

Table LXIII
Annual Uranium ^{233}U Discards to Sanitary/Storm Sewer
(gram)

Period	U	^{233}U	Cumulative U	Cumulative ^{233}U
CY 1947	-[96]	-	-	-
CY 1948	-	-	-	-
CY 1949	-	-	-	-
CY 1950	-	-	-	-
CY 1951 (6 mo.)	-	-	-	-
FY 1952	-	-	-	-
FY 1953	-	-	-	-
FY 1954	-	-	-	-
FY 1955	-	-	-	-
FY 1956	-	-	-	-
FY 1957	-	-	-	-
FY 1958	-	-	-	-
FY 1959	-	-	-	-
FY 1960	-	-	-	-
FY 1961	2	2	2	2
FY 1962	-	-	2	2
FY 1963	-	-	2	2
FY 1964	-	-	2	2
FY 1965	-	-	2	2
FY 1966	-	-	2	2
FY 1967	-	-	2	2
FY 1968	-	-	2	2
FY 1969	-	-	2	2
FY 1970	-	-	2	2
FY 1971	-	-	2	2
FY 1972	-	-	2	2
FY 1973	-	-	2	2
FY 1974	-	-	2	2
FY 1975	-	-	2	2
FY 1976	-	-	2	2
FY 1976A (3 mo.)	-	-	2	2
FY 1977	-	-	2	2
FY 1978	-	-	2	2
FY 1979	-	-	2	2
FY 1980	-	-	2	2
FY 1981	-	-	2	2
FY 1982	-	-	2	2
FY 1983	-	-	2	2
FY 1984	-	-	2	2
FY 1985	-	-	2	2
FY 1986	-	-	2	2
FY 1987	-	-	2	2
FY 1988	-	-	2	2
FY 1989	-	-	2	2
FY 1990	-	-	2	2
FY 1991	-	-	2	2
FY 1992	-	-	2	2
FY 1993	-	-	2	2
FY 1994	-	-	2	2

[96] Dash represents no transactions.

4.10.2 Trends and Interpretations

None.

4.10.3 Incidents

None.

5.0 Contributors to ID

5.1 Impurities

5.1.1 Enriched Uranium Above 20 percent ^{235}U

In most instances, pure metal has been shipped and received as 100 percent uranium since the weapons material flow was initiated. This was the most efficient way to handle these transfers, since most of the other facilities in the complex did not actually reanalyze the metal. Exceptions to this policy have been small and relatively infrequent shipments of metal to domestic paying customers and foreign countries. It should be pointed out that all SNM compounds received or shipped by the Y-12 Plant are corrected for impurities.

The SNM metal generated in the early days of weapons production at the Y-12 Plant was not as pure as that which was subsequently produced. The primary impurity was carbon. When these parts are returned to the Y-12 Plant for reprocessing into new parts, the overall ID may increase because in the exchange more SNM is being indicated as shipped in metal today than actually was received. Fortunately most of the production with a high carbon level has been returned. While this impurity situation has been identified, no total impact on the long-term ID has been computed.

5.1.2 Enriched Uranium Below 20 percent ^{235}U

The explanation for enriched uranium b: ·/ 20 percent ^{235}U is the same as described in 5.1.1 above.

5.1.3 Depleted Uranium

The most significant contributor to depleted uranium ID since 1954 has been caused by the inability of the Y-12 Plant to precisely quantify individual discard streams. Over the 40-year period of depleted uranium accountability, receipts and shipments have been well known.

Therefore, we can assume that the zero error in ID is offset by the error in discards.

BI n/a Receipts (actual) - shipments (actual) - EI n/a = ID + discards

5.1.4 Normal Uranium

The 40-year normal uranium material balance is reasonably accurate. However, in the early years stack losses and trackout were not measured, and discards to the sanitary and storm sewers were charged off on rough estimates.

5.1.5 Thorium

Thorium metal was accounted for at 100 percent in the Y-12 production cycle. Impurities in the thorium contributed to the ID.

5.1.6 Lithium

Significant quantities of lithium material were machined and crushed to a fine dust. Some unmeasured quantity ends up in the ventilation system, as mop water, cleanup solutions which impacts ID, and in estimated nonhomogeneous salvage awaiting recovery.

5.1.7 Deuterium

Impurities that are present in the lithium metal react with deuterium the same as lithium; and in many cases, the reaction productions distill out of the lithium deuteride at the reaction temperatures and condense wherever the vessel is cooler (lid and upper 2 or 3 inches of the reactor). This represents a loss of deuterium which is not accounted for.

5.2 Use of Factor Weights

5.2.1. Enriched Uranium Above 20 percent ^{235}U

It was pointed out earlier that 99.6 percent of the Y-12 Plant SNM inventory is measured. Of the remaining 0.4 percent, virtually all is carried on a factor weight that has been generated over years of recovery/cleanup campaigns. These factors have been generated using the best methods available to estimate the values, and the policy of conservatism in estimating waste was followed. In virtually all cases, the data base is somewhat minimal because of the cost involved or the opportunity to gather information. Some examples of factor weight usages follow.

a. Contamination of Lathes

A value of grams per lathe has been established by utilizing the tear-down situations to get (as near as possible) a complete decontamination value. These tear-down situations occur very infrequently and are avoided as much as possible because they involve loss from production of the lathe for as much as two months. Each month, each lathe is monitored with NDA instruments to detect any significant change in the held-up SNM from the previous month. This factored SNM value is used as an inventory value.

b. Oxidization of Chips

When machine turnings are generated, the heat of the cutting process causes the chip to oxidize. A coolant is used to prevent the ship from igniting, and they are collected and stored under a solution to further prevent oxidation. After cleaning, the chips are briquetted and stored in a plastic bag in a stainless steel can.

Regardless of the efforts expended, it is evident from metal yields after melting the chips that the oxidization of the chips is a real influence on the metal yield. For years the machining MBA had a general gain which apparently came from them receiving credit for the chips as 100 percent metal. Conversely, this also contributed to the general ID deficiency in casting. An attempt was made in the early 1960s to quantify the amount of oxide on the chips but accurate factors were very difficult and expensive to generate, and it was not until 1982 that acceptable factors for oxidization of chips were established and used. These factors affect correct recording of inventory in the machining and casting production areas; but more importantly, they eliminate the addition of oxygen as uranium metal to the SNM chips received into the casting process.

c. Carbon Molds

Carbon molds and crucibles become contaminated with SNM in the process of making casting pours. Eventually, these articles get broken and are shipped to the salvage/recovery operation where the contained SNM is put in a measurable state. Those molds and crucibles that have been used and remain in the casting MBA at inventory time contain SNM that is carried on a factor weight for inventory purposes.

These factors have been established by special recovery campaigns on carbon items with a one-use, two-use, three-use, etc., history. Such campaigns are not convenient when production rates are high, because they take special and separate handling and require a great deal of time. There is no reason to suspect great changes in the rate of holdup in carbon, and, as a result, these factor weights are not reestablished very often.

d. Filter Bag House and Ducts

A clean air system managed by the ...cilities Management Organization supplies air to the production areas, and this air is exhausted from these areas at a rate of 15 to 20 air changes per minute. As a result, SNM particles that would be airborne and vacuumed into a large duct work are filtered through high efficiency particulate air (HEPA) filters and a bank of bag filters.

From clean-out inventories and routine change out of the filters, data have been generated that are representative of SNM materials buildup within the ducts as well as the filters. Each month the air ducts are metered with NDA equipment to determine if a significant change has occurred, and periodically all of the filters are replaced. Until a clean out of the air ducts occurs, the build up of SNM contamination is factored, and the same is true for the bag filters until they are replaced. The HEPA filter SNM content is more accurately measured when recovered.

5.2.2 Enriched Uranium Below 20 Percent ^{235}U

Factored weights are used in the enriched uranium below 20 percent ^{235}U for equipment holdup and uranium compound inventories. These factors and estimates effect the ID.

5.2.3 Depleted Uranium

The depleted uranium ^{235}U value has historically been calculated by using a factor.

Average weights for various production part types for depleted uranium have been used since the 1950s. The difference between factored weights and actual weights is reflected in the ID.

5.2.4 Normal Uranium

Weights of normal uranium parts have not been factored but based on actual weights. This has contributed very little to the ID. Most of the ID occurred in discards and converting metal to compounds.

5.2.5 Thorium

Thorium weapon parts were based on actual weights. The primary contributor to the ID was discard of residues on estimated values.

5.2.6 Lithium

Lithium machine dust is transferred within the production cycle on factored weights.

5.2.7 Deuterium

In the production cycle, there is always a difference in the gram for gram deuterium (g/gD) for machine dust versus the blend g/gD. The machine dust is always lower and the difference is due to the pickup of moisture which causes lithium hydroxide to form. The lithium hydroxide reacts almost instantly with the carbon dioxide in the air forming lithium carbonate. This is a continuous loss of D_2 to the atmosphere that is never accounted for or written off to the atmosphere.

5.3 Plating, Absorption, etc., of Process Equipment

5.3.1 Enriched Uranium Above 20 Percent ^{235}U

This item contributes significantly to ID and is perhaps the most difficult of the general contributors to evaluate because these are materials that drop out of an active process stream and often take special recovery acts to determine their existence and quantity. For example, in 1980 a change was made from a long-term supplier of a chemical used in the solvent extraction process and while the chemical was purchased according to a standard set of specifications, the new supplier's chemical has an additive that caused an oxalate of uranium to precipitate in the extraction system. This oxalate did not process through the system and was a major contributor to the out-of-control SNM ID deficiency reported in May 1980. The oxalate SNM was washed out of the solvent extraction system eventually, but it was difficult to recognize its existence and also to recover it.

Problems with plating or absorption also occur in the interconnecting piping, ash leacher, oxide dissolver, evaporator system, and horizontal hold tanks that are in the salvage/recovery area. Holdup also occurs in systems other than solution flows such as the chip burner and CWS filters.

Many operational checks are made to detect and correct plating and other holdup problems with handling SNM-bearing solutions, but a method of using NDA equipment on the solvent extraction columns and the evaporator provides a means of monitoring their SNM inventory. The MC&A engineering function at the Y-12 Plant worked with the LANL to provide this monitoring capability.

5.3.2 Enriched Uranium Below 20 Percent ^{235}U

Uranium holdup in process equipment contributed to the above 20 percent ^{235}U ID. Material values were factored on a monthly basis and over the years plating and absorption played a role in the ID.

5.3.3 Depleted Uranium

Efforts were made to control the depleted uranium program, but plating, absorption, and holdup in process equipment had an impact on the ID.

5.3.4 Normal Uranium

Normal uranium was processed in depleted uranium production areas resulting in the mixture of normal uranium residues with depleted. The normal uranium accountability was calculated by difference resulting in IDs. These parts were weighed and did not contribute to the ID.

5.3.5 Thorium

Thorium metal is accounted for at 100 percent thorium. Weapons parts produced from thorium metal were shipped from Y-12 on actual values. However, residues were plated and absorbed on the process equipment resulting in IDs unable to be measured.

5.3.6 Lithium

The lithium process reported material holdup in equipment at estimated values for inventory. This resulted in IDs in lithium accountability balances.

5.3.7 Deuterium

Some of the deuterium process equipment is factored for deuterium content because of the difficulty of actual measurements. This contributed to the ID. One of the primary contributors to ID is high production rates. Comparison of throughput to ID proves the point. Another contributor is compressor losses. Significant losses were detected around the seals and pistons of the reciprocal compressors. Subsequent changes to sealed diaphragm compressors have eliminated most losses and improved ID performance.

5.4 Solids Discards

5.4.1 Enriched Uranium Above 20 Percent ^{235}U

The entire operation of the electromagnetic isotope separation process from CY 1943 through CY 1946 resulted in a salvage discard of 14 kg uranium at an average enrichment of almost 26 percent ^{235}U.

A major one-time discard by burial at Y-12 was the site residue cleanup from the United Nuclear Facility at Wood River Junction, Rhode Island. The Y-12 Plant was directed by the DOE in 1982 to accept this material and put in into the Y-12 burial grounds. There are 28,936 55-gallon drums of residue containing 16 kg of high enriched uranium fixed in concrete buried in a single use disposal site comprising about 2 acres at the west end of the plant on the crest of Chestnut Ridge (see footnote 10, page 25).

Residues from the various production areas, both above 20 percent ^{235}U and below 20 percent ^{235}U, are processed by the Salvage Recovery areas to the point that they are economically infeasible to recover. In the past, the solid materials were physically sampled with a chemical analysis of the sample. Currently, discard values are established with NDA instrumentation which is likely the best measurement possible since all of the SNM content of this low equity, heterogeneous material is evaluated. With a policy of conservatism existing, the new measurement probably allows the Y-12 Plant to claim more SNM from these discards now than in past years.

5.4.2 Enriched Uranium Below 20 Percent ^{235}U

The explanation described in 5.4.1 also applies to enriched uranium below 20 percent ^{235}U.

5.4.3 Depleted Uranium

Discards of depleted uranium to sewer and burial ground were not significant in the years 1946-1954, mainly because Y-12 was not processing much depleted plus the fact that turnings and chips and massive metal were recycled through the casting process.

During the period 1953-1959, approximately 1,800 55-gallon drums of depleted crucible oxide accumulated and was stored at Y-12; and in 1959, AEC gave permission to bury this material both in an unused oil pit and in the newly opened Bear Creek burial ground.

In September 1960, Pit Number 1 in the "new" Y-12 burial ground (Bear Creek) was dug, filled with depleted crucible oxide and covered. The beginning inventory oxide as of April 1, 1960, was 386,000 kg. It was found to be uneconomical to fill the concrete pit inside the Y-12 Plant perimeter to its capacity (estimate 275,000 kg) through the three port holes in the top. Only 192,205 kg is contained in the pit.

In the fourth quarter of FY 1964, the above material (192,205 kg) which had been deposited in loose form in an abandoned concrete pile pit identified as Building 9988-1 (behind Building 9201-1) within the Y-12 Plant area in CY 1959, we charged off the Y-12 inventory as a discard to burial ground to be consistent with the treatment of crucible oxide subsequently produced and consigned to Y-12 Plant Burial Ground Number 2.

Prior to August 1963, depleted chips and turnings had been briquetted and returned to casting as feed along with other massive metal scrap except for a five-month period from August through December 1960, when special approval was given to bury depleted chips and turnings. Materials such as carbon molds, floor sweepings, pickling solutions, processing sludges and foundry spills have routinely been discarded to the burial ground (X-10 until 1960) and sewer since depleted processing began about 1953.

A one-time approval dated August 5, 1965, was made to dispose of a large quantity (2,578,000 kg) of excess depleted uranium scrap in a pit of approximately 50,000 cubic feet under the present coal storage yard in the western exclusion area. This material was generated during disassembly of returned weapons and normal plant functions. The approval included all excess depleted uranium "now on hand, plus expected accumulations" through FY 1967. The NMC&A Department records show 1,762,652 kg under a coal pile.

5.4.4 Normal Uranium

The Y-12 Plant was rather heavily involved in the SRS normal slug program.

Normal uranium was used in process development for the Rover program. Approved Inventory Write-offs Number 133, FY 1953, shows a discard of normal uranium salvage from Rover development.

5.4.5 Thorium

In 1965, NMC&A Waybill 404 showed 576.9 [illegible] thorium contained in 4 drums and buried under the coal pile. This material [illegible] excess to Y-12 and ORNL needs.

5.4.6 Lithium

Solid discards had little impact on the lithium program ID. However, efforts were made to identify solid lithium discards to determine whether they were properly identified and accounted for and if the measurement basis for write-off was accurate.

5.5 Solutions Discards

5.5.1 Enriched Uranium Above 20 Percent ^{235}U

Solution discards follow the same measurement routine as solids discussed in 5.4.1.

5.5.2 Enriched Uranium Below 20 Percent ^{235}U

Solution discards follow the same measurement routine as solids discussed in 5.4.1.

5.5.3 Depleted Uranium

Discards of depleted uranium to sewer were not significant in the years 1946-1954, mainly because Y-12 was not processing much depleted plus the fact that turnings and chips and massive metal were recycled through the casting process.

5.5.4 Normal Uranium

Most of the discard activity for normal uranium solutions occurred in the 1950s. Compared to other materials since the 1960s, normal uranium would be considered a small production stream.

5.5.5 Thorium

Accountability data for thorium leaving the Y-12 Plant via East Fork Poplar Creek were based on proportional samples of flow taken at the entrance to New Hope Pond. These data were used to calculate the solution discard of thorium.

5.5.6 Lithium

The processing loss inherent in product forming and fabrication was not quantified. The finely divided material tends to spread as a dust and as such ends up in the ventilation system, the vacuum system on the floor, and in mop water not routinely measured.

5.6 Trackout

5.6.1 Enriched Uranium Above 20 Percent ^{235}U

Processing of SNM eventually generates SNM materials that get on the floor and consequently on the soles of employee's safety shoes. This material was measured by rather crude method that involved placing a very adhesive mat in front of the doors and measuring the material that was removed from the soles over a specified period of time. Tests had shown that the remaining SNM on the shoe soles normally wore off before the employee got out of the gate.

There was an incident in which an employee of the Y-12 Plant went to work at the Sequoyah Nuclear Power Plant and a microscopic chip of SNM metal was discovered embedded in the sole of his shoe. Since then, no employee can take his safety shoes off site unless authorized, and people visiting the production areas are required to wear shoe scuffs that also do not leave the processing areas. The physical controls resulted in better control and more reliable data for the trackout.

5.6.2 Enriched Uranium Below 20 Percent ^{235}U

No trackout program was in effect for enriched uranium below 20 percent ^{235}U in the processing areas serving this material. This contributed to the ID. However, a contamination control program was begun in 1983 wherein all employees must use shoe scuffs or company safety shoes that do not leave the processing area. Prior to 1983, personal shoes or company safety shoes had some possibility of removing radioactive materials from the operating areas to the environment.

5.7 Atmospheric Discards

5.7.1 Enriched Uranium Above 20 Percent ^{235}U

All stacks where SNM is processed are equipped with a monitoring system, and efforts are continuing to upgrade these measurements.

While every effort is made to reasonably state and monitor atmospheric discards, the systems used are not perfect and exceptions do occur. An example of the system working was demonstrated in 1981 when the industrial sewer samples highlighted a radical increase of SNM content. Investigative actions pinpointed the source as atmosphere, and further sampling established a specific quantity (approximately 7 kg SNM) for the unidentified discard. Actions were taken by the area to prevent such a release in the future, and current monitorings show a stable and expected discard rate.

It is not intended to imply that "all" discards to the atmosphere have been identified and measured. Two instances where unexpected findings of SNM occurred are in the cooling tower outside Building 9212 and a stack on the same building. In both cases, the quantities were minimal, but they aroused much attention within the Y-12 Plant management system because SNM showed up in areas where it was not supposed, or expected, to be.

5.7.2 Enriched Uranium Below 20 Percent ^{235}U

The explanation given in 5.7.1 applies to enriched uranium below 20 percent ^{235}U.

5.7.3 Depleted Uranium

Stacks located in the depleted uranium processing areas were not monitored until the early 1980s. A stack monitoring system was installed on a stack serving the depleted foundry in 1984.

5.7.4 Normal Uranium

Stacks serving areas processing normal uranium were not monitored until the early 1980s.

5.7.5 Thorium

No accountability records are available that show thorium atmospheric discards for Y-12.

5.7.6 Lithium

Stacks were used to serve the processing areas, but no losses were quantified for lithium.

5.7.7 Deuterium

No atmospheric discards were calculated for deuterium stack losses.

5.8 Miscellaneous

5.8.1 All Accountable Materials

A number of miscellaneous small contributions to ID uncertainty are measured such as the sanitary sewer, mop water, laundry water, contaminated oil, and others. Their contributions are very real but minimal in quantity.

A number of sources are not measured, e.g., contamination covered with paint, contamination in the floors, and other such minimal items that simply escape measurement.

6.0 Internal Control (Enriched Uranium Above 20 Percent ^{235}U)

6.1 Initial and Repetitive Measurements

There have traditionally been 24 active SNM MBAs in the Y-12 Plant, and 9 of these actually processed or changed the form of the materials they received. It is the responsibility of the production operation to establish content values for items when they have been generated or changed. This usually amounts to the item being weighed and an effort being made to assure the isotopic values. In cases where the material cannot be weighed, such as a fixed tank of solution, volume measurements are made. When SNM moves between MBAs, the shipper is required to input a transaction to the MC&A accounting system, and the subsequent receiver is required to verify the material and input to the MC&A accounting system a transaction indicating receipt of the material.

In many cases, the isotopic content of the items generated is assumed. For example, great care is taken to ensure the isotopic content of casting batch makeup for pours making cast parts. An elaborate system of cards for production control is assigned each cast part, but the isotopic content of the part is assumed until a product certification sample is needed. These parts are weighed and NDA-verified before transfer. Also, SNM product from the reduction operation (4.5 kg metal buttons) is made from rather elaborately measured batches of UF_4. All of these buttons are weighed upon being knocked out of the reduction vessel, but only one out of four are physically sampled for SNM content. These items are pointed out to dispel an idea that every item in the entire complex has a weight and chemical analysis for SNM associated with it. There is no reason to feel that this approach in establishing the SNM content of the items is inadequate.

6.2 Accountability Measurements

In so far as reasonably possible, the measurements made for accountability purposes utilize the measurements made for production. Control programs are administered for all instruments or analysis processes used to establish accountability values of SNM, and these control programs utilize standard materials and equipment that are traceable to national standards programs. Each operations area processing SNM must develop internal procedures to ensure the maintenance of calibration of each instrument or technique used to generate accountability measurement.

The most centralized control program for SNM measurement has been administered by Quality Services, formerly the Statistical Services Department. This group administers quality control and sample variability control programs to assess the precision of all analytical measurement techniques. Monitoring, technical oversight, and evaluation of this function are provided by professional statisticians. This group monitors the volume measurements including calibration of process vessels. Data generated from all of these measurement activities are used to characterize the statistical components needed to generate limit of error for shipments or receipts of SNM.

Each MBA has an NM custodian who is assigned the responsibility of ensuring that accountability records, procedures, and measurements are in compliance with the MC&A needs. Of prime importance to any system for accountability are the fundamental measurements made on transfers.

A general highlighting of the accountability measurements made at the Y-12 Plant is as follows:

a. <u>Mass Measurements</u>

Scales are located in each MBA that possess SNM, and all items entering or exiting the MBA are weighed. Scales are checked on each day of use with calibrated test weights and recalibrated on a schedule of approximately five weeks. The recalibration program is computerized, but obviously maintenance is made available on an as-needed basis. Primary masses at the Y-12 Plant are calibrated by the National Bureau of Standards (NBS) on a five-year frequency.

b. <u>Volume Measurements</u>

Approximately 1,000 gallons of liquid containing from 200 to 400 kg of SNM are measured each month as a part of the physical inventory. This material is transferred to calibrated storage tanks for sampling and volume determinations.

c. <u>Analytical Techniques</u>

The major techniques used in performing analytical determinations of SNM for accountability values are:

1. X-ray emission,
2. Titration,
3. Gravimetry,
4. Mass spectrometry, and
5. Some NDA methods.

d. <u>NDA Measurements</u>

NDA equipment has been used for many years at the Y-12 Plant for various qualitative and quantitative measurements. In most production areas, NDA instrumentation has been used to verify the isotopic enrichment of SNM for stream purity, verification of receipts/shipments between MBAs, and verification of physical inventory. Quantitative NDA systems are in place to cover low and high density solids and various solutions. NDA systems currently in use include a Segmented Gamma Scanner (SGS), an Active Well Coincidence Counter, and a Solution Assay System. Other systems include a Condensate Monitor used for detecting PPM quantities of SNM in process equipment and a portable Multi-Channel Analyzer system used to measure SNM holdup in equipment.

6.3 DYMCAS

At the Y-12 Plant, the accountability records system is a computerized network that collects transaction and other accountability data, processes it in accordance with records system needs, produces necessary transfer and ledger records, and provides the Y-12 Plant input to the DOE-HQ through NMMSS.

6.4 Internal Audit and Assessment Program

In addition to the controls and checks which are built into the system and which function on a day-to-day basis, one important aspect of the internal control system is a formal internal audit program. This program has the purpose of further determining whether the built-in controls and procedures are adequate to meet the safeguards program's needs and whether these procedures and mechanisms are being carried out on a consistent basis.

6.4.1 General Program Features

The Y-12 Plant MC&A internal audit program is coordinated and carried out by the NMC&A Department Assessments, Testing and Training (AT&T) staff. Various other qualified plant personnel, both with NMC&A and in other support groups, assist in performing this function.

6.4.2 Audit Programs and Work Papers

Specific audit programs are developed and prepared to ensure that proper procedures and practices are being followed for the control and accountability of SNM in the operating area. The audit steps in the audit program have a corresponding set of work papers to document and support the auditor's field work and audit conclusions.

6.4.3 Internal Audit Reports

A formal audit report is prepared for each audit conducted, identifying the areas examined, the techniques used in this examination, and the results of the audit. The report identifies those aspects of the system performance which result in strengthening the overall MC&A system and may specifically identify any recommendations for improvements. These recommendations can relate to proposed system changes or to the requ[illegible]d compliance with existing system procedures by specific responsible parties.

6.4.4 Audit Follow-ups

Where necessary, follow-up audits are conducted to determine if necessary improvements have been carried out.

6.4.5 Audit Report Distribution

Each internal audit report is distributed to the NMC&A Department Manager and to involved plant supervision and MBA custodians.

6.4.6 Internal Audit Topics

The Y-12 Internal Audit Program, as defined in Procedure Y20-NM-008, requires that the following areas be included:

- DYMCAS data base
- MBA inventory observation
- MBA inventory verification
- MBA procedures

- Technical audit to include data systems, measurements, and measurement control, statistical programs, and S/R differences
- TIDs
- Discards and waste
- Training
- Performance testing

The audit program is implemented by an audit plan which sets forth schedules for audits each fiscal year. Components of the MC&A system evaluated include NM access, NM accountability, measurements, and training. This overall audit program provides an assessment of the effectiveness of the MC&A system in deterring, preventing, detecting, and responding to the unauthorized removal of SNM from its authorized location. The program provides a verification of procedures and practices showing material control effectiveness. The program identifies deficiencies and tracks corrective actions.

Specific topic questionnaires have been developed in order to ensure that every area is examined. These questionnaires are based on requirements in DOE orders, Inspection and Evaluation (I&E) Standards and Criteria, and the MC&A Plan.

6.5 Emergency Plans

Emergency conditions are assessed in accordance with Procedures Y20-NM-105 and Y20-NM-009, Section 4.2.2.5. The Y-12 Plant Emergency Plan to respond to and resolve conditions that indicate possible loss of control of NM is described below.

Loss of control of NM may take two forms. First, is an operational equipment failure which may result in an uncontrolled discharge of NM to the environment. Second, is potential theft or diversion of NM as addressed in DOE Order 5633.3A.

An operational equipment failure is not felt to be subject within the context of safeguards and security as related to NM control and accountability and therefore is not discussed in this plan.

A single emergency plan to respond to and resolve conditions that indicate possible loss of control of NM is not used at the Y-12 Plant. Instead a series of graded responses to a spectrum of threats have been provided. These graded responses are in the form of a series of procedures. The procedures are written to conform to the letter and/or the intent of pertinent DOE orders.

The Y-12 Plant has a system of procedures which are numbered by series to indicate the subject area. The 40-series of procedures are Emergency Procedures.

Because the Y-12 Plant does not process NM other than depleted uranium, enriched uranium, lithium-6, and deuterium, no major concern exists with respect to environmental compatibility from an MC&A point of view.

Safety and health with respect to NM are under the purview of the Y-12 HSEA Organization. Plant procedures are in the 70-series of Safety Procedures and the 50-series of Radiation Safety Procedures.

Security during emergency conditions is under the jurisdiction of the Protective Services Organization. Physical security is governed by the 20-PS series of procedures and the Plant Shift Superintendent's Response Manual. MC&A responses to emergencies are described in the 40-series of procedures and applicable Y20-NM procedures.

Emergency operations, operational organizations, the identity of persons directing emergency responses, command and control functions, NM alarm and evaluation procedures, MC&A threat response, and special inventories are all covered in the above-referenced procedures.

6.6 Statistical Control Limits and Reporting

Normal reporting of enriched uranium ID control limits to the DOE and its predecessors has been the Monthly Balance Report (MBR). Some variations existed in the statistical evaluation of such inventory data. After researching historical records and consulting with statisticians E. W. Bailey and E. E. Johnson. the following practices were generally being used in the same time periods indicated.

6.6.1 FY 1947-FY 1956

In the early years of this period, the inventory and MBR showed the inventories and MUF for the total plant, for uranium enriched in ^{235}U grouped below and above 75 percent. Also included were inventories and MUFs for some individual process areas. For each of these inventories and MUFs, the associated 95 percent confidence limits of error were reported. In the latter years, the MBR showed the total inventories and MUFs, as above, but only included individual area MUFs (without limit of error) for those which were felt to contribute to the total MUF.

The limits of error were generated by propagation of error and not by observation of the variation of the monthly MUFs. Estimates of random and systematic errors in weighing, sampling, analysis, and as[illegible] were assigned to every batch of material on inventory or transferred between MBAs during the month. Experiments were also conducted to obtain estimates of those errors in addition to quality control samples submitted to the laboratories.

When limits of error indicated significant MUFs, explanations were given in the letter transmitting the report to the AEC. Since the report was made to AEC, it was assumed they would take any action deemed appropriate, after considering any measures Y-12 had taken. It was obvious from the records that toward the latter part of this period, less detail (especially individual area MUFs) was being reported to AEC. In none of the reports could it be found what information was actually required by AEC.

6.6.2 FY 1957-FY 1965

The ID control charts of individual MBAs were started in 1957 for the lithium accounts and in 1959 for the uranium accounts. Prior to FY 1966, limits were calculated based on one or more years of FY data using an "eyeball review" of charts to determine what years to include in the calculations.

6.6.3 FY 1966-FY 1973

The FY 1966 limits were based on FY 1966 data. Starting with FY 1967, limits for each FY were based on the previous FY data. If the variability increased during the last half of a previous year, the limits for the ensuing year were based on the data from the last half of the previous year.

6.6.4 FY 1974-FY 1978

A closer examination of the ID data in 1974-1975 indicated that some of this data appeared to be autocorrelated. Autocorrelated data is due to the ending inventory in a monthly ID. It is the beginning inventory in the next month's ID. If an autocorrelation technique is not applied of the data, the limits may be slightly too wide. To obtain better estimates of the limits starting with FY 1976, an autocorrelation technique was applied to ID data per report Y/DJ-16513.

6.6.5 FY 1979-Present

Beginning in 1979, the calculation of ID limits for uranium was adjusted for throughput (determined for previous 60 months); and these modified limits became our basis for monthly evaluations. However, ID charts without the throughput adjustment were also continued and are available to the current date.

For the earliest period, when to report ID control incidents appeared to be at the discretion of plant management.

7.0 Security—Personnel and Physical (Enriched Uranium Above 20 Percent ^{235}U)

7.1 Activities and Security Measures—1943-1945

- Late 1943, first product grade material produced
- First MAA, Building 9203 - Rooms 6 and 8
- Established MAAs in Building 9206
- Background investigation which continued after employment
- Guard-controlled access/egress
- Color-coded badge system
- Polygraph examinations
- Outside doors locked
- Personal recognition system
- Undercover agents
- Emphasis on protection of classified material and technology

7.2 Activities and Security Measures—1945-1951

- Severe drop of plant population
- Operations consolidated
- Administration of protection program transferred from military to contractor, Tennessee Eastman
- Uranium processing activities transferred from Building 9206 to Building 9212 complex
- Entire complex fenced
- Portion of complex facing Bear Creek double-fenced
- Guard towers on all four corners of complex
- Personnel portal (rotogate) and vehicle portal
- Double-badging system
- Access approval from AEC HQ required
- Building 9212 complex basically autonomous—dedicated maintenance force, laboratory, administrative offices, and cafeterias
- Three MAAs - A-, C-, and D-Wings, in complex—access to each controlled by a guard and double-badging system
- Background investigations continue only prior to employment with periodic updates
- Physical protection of SNM in transit - material transported between Y-12 and K-25
  - Truck with armed guard
  - Armored escort vehicle
  - Radio contact between truck, escort vehicle, and both plants
  - Guard at loading dock during unloading

Activities and Security Measures—1951-1960

- Increased plant employment
- Building 9212 expanded - D-Wing, MAA
- Building 9212 added E-Wing, MAA
  - Double-badging system
  - Guards controlling access
- Additional MAAs established for processing lithium in Buildings 9998, 9215, 9201-6, 9204-4
  - Double-badging system
  - Guards controlling access
- Lithium processing discontinued in Building 9204-4 in January 1955 and process operations transferred to Building 9204-2
- Fencing extended to enclose new processing facility within the Building 9212 complex
- Background investigations continue
- Polygraph discontinued in 1952

Activities and Security Measures—1960-1970

- Basically the same as previous period (1951-1960)
- Instances where scrap containing depleted uranium or thorium alloys was inadvertently sold to metal scrap dealers

the contract administrator for the Y-12 Plant, and authorization to use the document to adjust the SNM records is given by the signature of the MC&A Branch director.

8.6 Headquarters Reviews

Before MC&A became joined with the Safeguards and Security function in AEC-HQ, a very thorough review of the appraisal work papers, both technical and audit, was performed. In recent years, the HQ review has been directed primarily toward security with cursory reviews of MC&A. However, during the last field office appraisal of the Y-12 Plant, a member of the MC&A staff in HQ participated in the appraisal. The review activity that has been done by HQ has been in the context of visiting the plant as opposed to inspection of records at the Federal Building. While the reviews were not in depth, the DOE-ORO MC&A function has not received severe criticism.

9.0 Source Documents

1. Bulletin GM-PRO-2, Serial No. 95, Accounting for Source and Fissionable Materials, August 15, 1951.

2. Report upon Review of SF Material Accounting System and Accounting Procedures; Lybrand Ross Bros., and Montgomery, January 20, 1950.

3. Review of SF Materials Accounting System and Maintenance Methods; Hydrocarbon Research, Inc., October 31, 1950.

4. Review of Accounting Program: Dr. Marvin M. Mann, AEC Headquarters; K. W. Willet, Superintendent Raw Materials Department, DuPont; Andres de la Garza, Senior Statistician, K-25 Plant, Union Carbide; L. M. Knight, Laboratory Director, General Electric Co., Hanford; Dr. Jane Hall, Assistant Director, LASL; and John T. Bobbitt, Assistant Laboratory Directory, Argonne, January 31, 1956.

5. Review of AEC Nuclear Materials Management Systems; Stanford Research Institute, August 1962.

6. Nuclear Materials Control Study Group Report on Comparability of Dow Chemical Company, Rocky Flats Plant, and Union Carbide Nuclear Company, Y-12 Plant, Highly Enriched Uranium Operations, June 1963.

7. Statistical and Inventory Procedures applied to Nuclear Materials Management; Stanford Research Institute, April 1966.

8. Explanation of Annual Inventory Difference (ID) at the Oak Ridge Y-12 Plant, Document No. Y/LA-971, October 6, 1977.

9. Nuclear Materials Control and Accountability Procedures, Y20-NM series, December 30, 1987 to December 31, 1993.

10. Control of Deuterium and Enriched Lithium at the Y-12 Plant; W. B. Kenna, Y/DG-16900, November 7, 1984.

11. Historic Accountable Radionuclide Releases at the Y-12 Plant; E. Owings, W. B. Kenna, and M. S. Franklin, Y/DG-17574, Rev. 1, September 16, 1985.

12. Inventory Differences (IDs) and Throughput - Beginning Inventory Plus Receipts (BI+R) by Fiscal Year and Cumulative IDs - 1965 to 1991; Memo W. H. Hopwood, Jr. to J. E. Keyes, April 3, 1992.

13. Control of Nuclear Materials at the Y-12 Plant; R. A. Harris, ORO-203160, September 21, 1983.

14. DOE Order 5633.3A, Control and Accountability of Nuclear Materials, February 12, 1993.

15. Materials Control and Accountability (MC&A) Plan, Y/DG-19839, Rev. 1, January 1992.

16. Report Explaining Historical Material Unaccounted For (MUF); Memo J. M. Case to H. D. Hickman, January 14, 1977; Attachment Y/LD-787, P. E. Wilkinson, January 14, 1977.

17. Revised Report—Coal Pile Burial During 1965/1966; Memo T. C. Myhre to T. R. Butz, November 10, 1983; Attachment Y/DS-164, Rev. 1, November 10, 1983.

18. Enriched Uranium Inventory Difference (ID) Control Limits and Reporting; Memo W. H. Hopwood, Jr. to M. L. Jones, April 26, 1984.

19. Interpreting MUFs; Memo Victor P. Lowe, Jr. to E. Owings, August 25, 1977.

20. Super Kukla Material; Memo D. T. Sissom to W. T. Mee, October 8, 1984.

21. AEC Inventory Reports, LXXXV-1409, 1-1A, Book 15, CY 1947-November 1950; Location 7-7-6, Records Center, Building 9711-5.

22. AEC Inventory Reports, LXXXV-1411, 1-1A, Book 17, CY December 1950-CY 1952, Location 7-7-6, Records Center, Building 9711-5.

23. AEC Monthly Inventory and Material Balance Reports, LXXXV-1781, 1-1A, Book 37, July 1952-December 1953, Location 7-7-6, Records Center, Building 9711-5.

24. AEC Monthly Inventory and Material Balance Reports, LXXXV-4633, 1-1A, July 1953-December 1954, Location 7-7-6, Records Center, Building 9711-5.

25. AEC Monthly Inventory and Material Balance Reports, LXXXV-4501, 1-1A, July 1954-December 1955, Location 7-7-6, Records Center, Building 9711-5.

26. AEC Monthly Inventory and Material Balance Reports, LXXXV-3842, 1-1A, January 1956-December 1956, Location 7-7-7, Records Center, Building 9711-5.

27. AEC Monthly Inventory and Material Balance Reports, LXXXV-3843, 1-1A, January 1957-December 1957, Location 7-7-7, Records Center, Building 9711-5.

28. AEC Monthly Inventory and Material Balance Reports, LXXXV-4032, 1-1A, January 1958-December 1958, Location 7-7-7, Records Center, Building 9711-5.

29. AEC Monthly Inventory and Material Balance Reports, LXXXV-4620, 1-1A, January 1959-December 1959, Location 7-7-7, Records Center, Building 9711-5.

30. AEC Monthly Inventory and Material Balance Reports, LXXXV-4646, 1-1A, January 1960-December 1960, Location 7-7-8, Records Center, Building 9711-5.

31. AEC Monthly Inventory and Material Balance Reports, LXXXV-5952, 1-1A, January 1961-December 1961, Location 7-7-8, Records Center, Building 9711-5.

32. AEC Monthly Inventory and Material Balance Reports, LXXXV-5199, 1-1A, January 1962-December 1962, Location 7-7-8, Records Center, Building 9711-5.

33. AEC Monthly Inventory and Material Balance Reports, LXXXV-5244, 1-1A, January 1962-February 1963, Location 7-7-8, Records Center, Building 9711-5.

34. AEC Monthly Inventory and Material Balance Reports, YKK-687, 1-1A, July 1962-December 1962, Location 1-7-8, Records Center, Building 9711-5.

35. AEC Monthly Inventory and Material Balance Reports, Y/DG-159, 1-1A, January 1993-June 1993, Location 1-7-8, Records Center, Building 9711-5.

36. AEC Monthly Inventory and Material Balance Reports, Y/DG-163, July 1963-December 1963, Location 1-7-8, Records Center, Building 9711-5.

37. AEC Monthly Inventory and Material Balance Reports, Y/DG-165, 1-1A, January 1964-June 1964, Location 1-7-8, Records Center, Building 9711-5.

38. AEC Monthly Inventory and Material Balance Reports, Y/DG-170, 1-1A, July 1964-December 1964, Location 1-7-8, Records Center, Building 9711-5.

39. AEC Monthly Inventory and Material Balance Reports, Y/DG-173, 1-1A, January 1965-June 1965, Location 1-7-8, Records Center, Building 9711-5.

40. AEC Monthly Inventory and Material Balance Reports, Y/DG-174, 1-1A, July 1965-December 1965, Location 1-7-8, Records Center, Building 9711-5.

41. AEC Monthly Inventory and Material Balance Reports, Y/DG-185, 1-1A, January 1966-July 1966, Location 1-7-8, Records Center, Building 9711-5.

42. AEC Monthly Inventory and Material Balance Reports, Y/DG-235, 1-1A, July 1966-December 1966, Location 1-7-8, Records Center, Building 9711-5.

43. AEC Monthly Inventory and Material Balance Reports, Y/DG-236, 1-1A, January 1967-August 1967, Location 7-10-3, Records Center, Building 9711-5.

44. Monthly Material Balance Reports, Y/DG-556, 1-1A, July 1967-June 1968, Location 7-10-3, Records Center, Building 9711-5.

45. Monthly Material Balance Reports, Y/DG-557, 1-1A, July 1968-June 1969, Location 7-10-3, Records Center, Building 9711-5.

46. Monthly Material Balance Reports, Y/DG-861, 1-1A, July 1969-December 1969, Location 7-10-3, Records Center, Building 9711-5.

47. Monthly Material Balance Reports, Y/DG-1393, 1-1A, January 1970-June 1970, Location 7-10-3, Records Center, Building 9711-5.

48. Monthly Material Balance Reports, Y/DG-1660, 1-1A, July 1970-June 1971, Location 7-10-3, Records Center, Building 9711-5.

49. Monthly Material Balance Reports, Y/DG-2098, 1-1A, July 1971-December 1971, Location 7-9-2, Records Center, Building 9711-5.

50. Monthly Material Balance Reports, Y/DG-2297, 1-1A, July 1971-June 1972, Location 7-9-2, Records Center, Building 9711-5.

51. Monthly Inventory and Material Balance Reports, Y/DG-2855, 1-1A, July 1972-December 1972, Location 7-9-2, Records Center, Building 9711-5.

52. Monthly Material Balance Reports, Y/DG-3122, 1-1A, January 1973-June 1973, Location 7-9-2, Records Center, Building 9711-5.

53. Monthly Material Balance Reports, Y/DG-3525, 1-1A, July 1973-December 1973, Location 7-9-2, Records Center, Building 9711-5.

54. Monthly Material Balance Reports, Y/DG-5188, 1-1A, January 1974-June 1974, Location 7-9-2, Records Center, Building 9711-5.

55. Monthly Material Balance Reports, Y/DG-5477, 1-1A, July 1974-December 1974, Location 7-9-2, Records Center, Building 9711-5.

56. Monthly Material Balance Reports, Y/DG-5754, 1-1A, January 1975-June 1975, Location 7-9-2, Records Center, Building 9711-5.

57. Monthly Material Balance Reports, Y/DG-6151, 1-1A, July 1975-December 1975, Location 7-9-2, Records Center, Building 9711-5.

58. Monthly Material Balance Reports, Y/DG-7232, 1-1A, January 1976-June 1976, Location 7-9-2, Records Center, Building 9711-5.

59. Monthly Material Balance Reports, Y/DG-7446, 1-1A, July 1976-September 1976, Location 7-9-2, Records Center, Building 9711-5.

60. Monthly Material Balance Reports, Y/DG-8616, 1-1A, October 1976-March 1977, Location 7-9-3, Records Center, Building 9711-5.

61. Monthly Material Balance Reports, Y/DG-8683, 1-1A, April 1977-September 1977, Location 7-9-3, Records Center, Building 9711-5.

62. Monthly Material Balance Reports, Y/DG-9727, 1-1A, October 1977-March 1978, Location 7-9-3, Records Center, Building 9711-5.

63. Monthly Material Balance Reports, Y/DG-9985, 1-1A, April 1978-September 1978, Location 7-9-3, Records Center, Building 9711-5.

64. Monthly Status Reports, M-742, Y/DG-11776, 1-1A, October 1, 1978-September 30, 1979, Location 7-11-5, Records Center, Building 9711-5.

65. Monthly Status Reports, M-742, Y/DG-13583, 1-1A, October 1, 1979-September 30, 1980, Location 2-10-7, Records Center, Building 9711-5.

66. Monthly Status Reports, M-742, Y/DG-15054, October 1, 1980 to September 30, 1981, Location 9-6-11, Records Center, Building 9711-5.

67. Monthly Status Reports, M-742, Y/DG-15748, 1-1A, October 1, 1981 to September 30, 1982, Location 4-4-3, Records Center, Building 9711-5.

68. Monthly Status Reports, M-742, Y/DG-16386, 1-1A, October 1, 1982 to September 30, 1983, Location 4-4-2, Records Center, Building 9711-5.

69. Monthly Status Reports, M-742, Y/DG-17086, 1-1A, October 1, 1983 to Septmber 30, 1984, Location 7-12-7, Records Center, Building 9711-5.

70. Monthly Balance Reports, M-742, Y/DG-17710, 1-1A, October 1, 1984 to September 30, 1985, Location 4-3-1, Records Center, Building 9711-5.

71. Monthly Balance Reports, M-742, Y/DG-18348, 1-1A, October 1, 1985 to September 30, 1986, Location 50-16-12, Records Center, Building 9711-5.

72. Monthly Balance Reports, M-742, Y/DG-19009, 1-1A, October 1, 1986 to September 30, 1987, Location 12-4-87, Records Center, Building 9711-5.

73. Monthly Balance Reports, M-742, Y/DG-19589, 1-1A, October 1, 1987 to September 30, 1988, Location 48-20-22, Records Center, Building 9711-5.

74. Monthly Balance Reports, M-742, Y/DG-20118, 1-1A, October 1, 1988 to September 30, 1989, Location 41-8-21, Records Center, Building 9711-5.

75. Monthly Balance Reports, M-742, Y/DG-21658, 1-1A, October 1, 1989 to September 30, 1990, Location 2-14-3, Records Center, Building 9711-5.

76. Monthly Balance Reports, M-742, Y/DG-23675, 1-1A, October 1, 1990 to September 30, 1991, Location 25-6-19, Records Center, Building 9711-5.

77. Monthly Balance Reports, M-742, Y/DG-24786, 1-1A, October 1, 1991 to September 30, 1992, Location 25-6-19, Records Center, Building 9711-5.

78. Monthly Balance Reports, M-742, Y/DG-25490, 1-1A, October 1, 1992 to September 30, 1993, NMC&A Vault.

79. Monthly Balance Reports, M-742, Y/DG-25990, 1-1A, October 1, 1993 to September 30, 1994, NMC&A Vault.

80. Miscellaneous Reports of the Electromagnetic Process, 1943 through 1948, LXXXV-3731, 1-1A, Location 40-15-6, Records Center, Building 9711-5.

81. Enriched Uranium 1900 Cycle Ledger, LXXXV-4942, 1-1A, FY 1959, Location 7-3-5, Records Center, Building 9711-5.